

BRITISH Soviet, French, and Dutch **BATTLESHIPS** of World War II

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LINE DRAWINGS BY

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Preface

Battleships and battlecruisers are warships of a bygone age, but for the first several decades of the twentieth century they were regarded as the ultimate weapon of sea power by the major navies of the world. With their large guns, heavy protection, and large displacement, they were accorded the compliment of being termed "capital ships." Until World War II, it was axiomatic that capital ships were considered the basic measure of relative naval power. Now they are merely the vanished symbols of a past age of sea power.

During most of the first half of the twentieth century, until air power made them obsolete, the number, characteristics, and availability of capital ships fundamentally influenced foreign policy and naval strategy. From the onset of the *Dreadnought* era, government officials, naval officers, civilian engineers and technicians, and laymen debated the complex problems of determining how many capital ships were necessary, their desired characteristics, and the best means of deploying and operating battle fleets, which were based on the battleship.

Two epochal developments during World War I significantly influenced the course of capital ship design:

- The development of the submarine as an effective combatant type forced the designers of capital ships to provide reasonable protection against torpedo attack.
- Similarly, the development of aircraft prompted interest in antiaircraft gunnery and in heavier deck armor to resist bombs.

In the years following World War I, the supremacy of the battleship was challenged by the advocates of air power. They insisted, accurately but prematurely, that the primacy of the capital ship was doomed by air power. The success of U.S. Army aviators under the leadership of General William "Billy" Mitchell in sinking a destroyer, light cruiser, and three obsolete battleships (most notably the ex-German *Ostfriesland*) in rather sensational (and one-sided) ordnance trials in 1921 and 1923 inflamed the controversy. Battleships were not defenseless and certainly not without any protection, but they did succumb to a new and more dangerous foe. For the next two decades, there was a proliferation of periodicals and books that forecast the demise of battleships under air attack, either at sea or in port. Inevitably, these developments influenced the design of new capital ships.

The Washington Naval Treaty of 1922 (and the subsequent London Naval Treaty of 1936) also had a profound effect on the design of capital ships. The treaty established two basic limitations on capital ship characteristics: the displacement was limited to a maximum of 35,000 tons "standard," and the maximum bore of the main-battery guns was set at 16 inches. These treaty limitations accelerated technological improvements that promised to save weight in warship construction; there was an extreme emphasis on weight control in all aspects of warship design, armament, arrangement, and construction. Even so, *all* navies building capital ships violated the treaty limitations to some extent. The London Naval Treaty of 1930 played a minor role in the history of capital ship design, as its major accomplishments involved

cruiser tonnage and limitations. However, the discussions revealed a better relationship between the United States and Great Britain than had been demonstrated at the Geneva Disarmament Conference three years before. From this time on there would be a growing estrangement with Japan.

The keel-laying of the French battlecruiser *Dunkerque* in 1932^{24. XII. 31 (p. 79)} heralded the start of a second great capital shipbuilding race, similar to that preceding the outbreak of World War I, involving fewer, but much larger, ships. By 1950, when the last battleship (the *Jean Bart*) was finally completed, new capital ships had been built by the United States, Japan, France, United Kingdom, Germany, and Italy. Several capital ships were actually laid down in the Soviet Union, while capital ship construction was formally projected in the Netherlands and Spain.

Even now, an air of fascination and mystery surrounds these giant warships, and some have been accorded near-legendary places in naval history. The *Prince of Wales*, whose sinking in December 1941 heralded the end of the battleship era, and the then-incomplete *Jean Bart*, whose escape from the advancing German armies just before the fall of France in 1940 is an epic of naval engineering, fall into this category, as do the classic American battleships of the *Iowa* class, the German *Bismarck* and *Tirpitz*, and the Japanese *Yamato*, *Musashi*, and *Shinano*.

This study, which will be done in three volumes, provides a detailed technical history of the design, construction, and operation of all battleships and battlecruisers, of vintage subsequent to 1930, including ships completed, laid down, or only projected. Volume I, *United States Battleships in World War II*, has already been published. This volume will deal with the capital ships of the Allied powers—Great Britain, France, the Netherlands, and the Soviet Union. Volume III will be concerned with the capital ships of Spain and the Axis powers—Germany, Italy, and Japan. Because of the diverse names in each navy, a tabulation of deck terminology by navy has been provided in this volume to assist the reader.

Although there is extensive literature describing the histories of the various battleships and battlecruisers, the available data on their technical characteristics have been rather limited and contradictory, with virtually no effort having been made to describe the ships from a technical standpoint, or with emphasis placed on their design development and construction.

It is believed that these noteworthy ships have been given a thorough treatment here in a study that presents relatively complete plans as well as extensive technical data covering their characteristics and performance. The operational careers of the ships are chronicled, followed by detailed analyses of outstanding incidents as they pertain to design adequacy—particularly from the standpoint of damage resistance. Research over a period of more than two decades has made extensive use of authoritative (and frequently official) source material, some of which has never before been published.

During the research, writing, and drawing of plans for this volume, many individuals and offices in the United States, Europe, and Japan have offered valuable assistance.

The chapters concerning British battleships could not have been completed without the cooperation of the Ministry of Defence and the Director General of Ships, Bath. In addition, several individuals provided substantial assistance that must be acknowledged: Dr. Ian Buxton provided invaluable aid not only in giving generously of data from his own personal files, but also in visiting the Admiralty at Whitehall on behalf of the authors. Mr. F. S. Sutherby, who served as an assistant to the Director of Naval Construction, Sir Stanley Goodall, reviewed early drafts of the manuscript and provided helpful insights into the design of these ships. Vickers Armstrongs also aided in the preparation of the manuscript on the *King George V* class, providing the

authors with much detail design information from their archives. Among the various shipyards and major engineering firms consulted were John Brown & Co., Clydebank; Cammell Laird, Birkenhead; Fairfield Engineering and Shipbuilding Co.; Swan Hunter and Wigham Richardson; and Yarrow. HMS *Excellent* provided the photographs of damage to the *Prince of Wales* and *Duke of York*.

For the detailed study of the loss of the *Prince of Wales*, the technical and historical analysis was greatly aided by the cooperation of several survivors: the executive officer, Commander A. G. Skipwith, RN (Retired); the gunnery officer, Captain Colin McMullen, RN (Retired), and an engineering officer, Vice Admiral D.B.H. Wildish, RN (Retired), then a lieutenant commander. These interviews contained much discussion on the testimony taken by the Bucknill Committee during a review of the loss of the *Prince of Wales* in 1942. Particular thanks are due to Vice Admiral Wildish and Mr. Patrick Mahoney, who provided invaluable analyses of battle damage reports and gave insights into how, when, and why damage occurred.

The chapters on the French *Dunkerque* and *Richelieu* reflect the sympathetic and cooperative attitude of the French Naval Attaché and the French Military Mission, Washington. Similarly, the Service Technique des Constructions et Armes Navales in Paris, and the Chantiers de l'Atlantique, St. Nazaire, were tremendously helpful. The late Henri Le Masson and M. Jean Meirat unselfishly gave much of their time and also data from their private collections, which included interviews with individuals familiar with the design and operation of these vessels. Mr. Shizuo Fukui provided the authors with much technical information, including data seized by the Germans in 1940 during the occupation of France and subsequently forwarded to the Japanese Navy when the *Richelieu* was deployed to the Far East in 1944.

As a result of this outstanding collaboration and assistance, much never-before-published source material has been available to the authors. Hence, the authors are confident that this volume presents the first complete technical discussion of the French capital ships of the *Dunkerque* and *Richelieu* classes. Regarding the physical characteristics and the general description of the detailed design of these ships, this is the most accurate account possible, since much of the original material was lost during the German occupation of France in 1940.

The late R. F. Scheltema de Heere, former Deputy Naval Constructor, Royal Netherlands Navy, provided source materials and reviewed in detail the narrative regarding the Dutch battlecruiser design program. This data was supplemented by materials and data provided by Mr. L. L. von Münching, Chief Librarian of the Royal Netherlands Navy. In addition, Mr. de Heere also reviewed the French and British designs discussed in this volume and provided some valuable insights.

The section on Russian capital ships owes its present state of completion to the generosity of Mr. Rolf Erikson and Mr. Jürgen Meister, long-time collaborators in the systematic study of the history and ships of the Soviet Navy. Mr. Matthew Forrest, formerly executive vice president of Gibbs and Cox, Inc., kindly permitted complete access to that firm's historical archives regarding capital ship design studies for the Soviet Union during 1937–39. Mr. A. D. Baker III was similarly helpful regarding source data detailing foreign technical assistance to the Soviet Union.

The illustrations for this study are worthy of special comment. Official plans at times vary in detail from the ships as built, are sometimes poorly preserved, and in some instances have become so illegible as to be considered incomplete. In producing the highly detailed and accurate line drawings, Mr. Thomas G. Webb, marine designer and free-lance illustrator, strived to ensure accuracy in developing the class outboard profiles and overhead views by obtaining details through diligent examination of literally scores of photographs of the ships. The vast collection of original blueprints was carefully studied in order to produce the most accurate details concerning general

arrangements, armor, and structural configuration and hull form, making it possible to complete a most painstaking and involved effort in preparing the line drawings.

Mr. Richard Van Hooff, a professional naval architect who is fluent in Dutch, French, and German, has been invaluable in ensuring the proper interpretation and translation of foreign source materials.

Other individuals whose interest and enthusiasm contributed to the completion of this project are Mr. John Campbell, M. Paul Morrell, Mr. Stratford Morse, Captain A. P. Laget, French Navy; Captain Sanner, French Navy; Rear Admiral Chaline, French Navy; and Rear Admiral Buckley, Royal Navy. Several members of the U.S. Naval Institute Staff (Carol Swartz, Beverly Baum, and Frank Uhlig) have participated in the development of this study, with the former senior book editor, Lieutenant Commander Arnold S. Lott (USN Ret.) having spent many hours reducing the many reams of rough manuscript to this final form.

The authors are particularly grateful for the substantial help provided by official sources. Naturally, the authors are solely responsible for any errors of fact or interpretation that may occur in this volume.

Lastly, special credit goes to three people who, through long years of encouragement and patience, have become battleship experts by marriage, as it were—the co-authors' wives, Loretta M. Garzke and Joan M. Dulin, and the illustrator's wife, Adrienne Webb.

Deck Designations

<i>United States Navy</i>	<i>Italian</i>	<i>German</i>	<i>French</i>	<i>Japanese</i>	<i>Dutch</i>	<i>Royal Navy</i>	
Tank Top	Stiva	Stauung	Toles de Ballast	Tank Top	Binnenboden	Tank Top	
3rd Platform		Unteres Plattformdeck		1st Hold Deck			
2nd Platform	Copertino Intermedio	Mittleres Plattformdeck		2nd Hold Deck		Lower Platform	
1st Platform	Copertino Superiore	Oberes Plattformdeck	Plateforme	Platform	Vierde Tusschendeck	Upper Platform	xi
Fourth Deck		Panterdeck	Deuxième Faux Pont	Lower	Derde Tusschendeck	Lower Deck	
Third Deck	II Corridoio	Zwischendeck	Premier Faux Pont	Middle	Tweede Pantserdek	Middle Deck	
Second Deck	I Corridoio	Batteriedeck	Pont Principal	Upper	Eerste Tusschendeck	Main Deck	
Main Deck	Coperta	Oberdeck	Premier Pont	Flying Deck	Bovendeck	Upper Deck	
01 Level	Castello	Aufbandeck	Pont du Chateau		Slopendek	Shelter Deck	
02 Level	Tug A	Unteres Bruckendeck	Plateforme 2		Dek H	Boat Deck	
03 Level	B	Unteres Mastdeck	Plateforme 3		Dek K	No. 2 Platform	
04 Level	C	Oberes Mastdeck	Plateforme 4		Dek L	Signal Deck	
05 Level	D	Admiralbrücke	Plateforme 5		Dek M	Lower Bridge	
06 Level	E		Plateforme 6		Dek N	Upper Bridge	

BATTLESHIPS



CHAPTER ONE

Introduction

Hheavy gun battleships and battlecruisers, long considered the ultimate embodiment of naval power, have now disappeared from the oceans of the world, the victims of technological progress. The final evolution of these ships was highly accelerated during World War II, where in a short time they reached their zenith—as illustrated by the *Hood-Bismarck-Prince of Wales* battle in May 1941—and then became obsolete by December 1941, when the *Prince of Wales* and *Repulse* were sunk in the South China Sea. The last ships were fast, powerful, and well protected.

The modern battleship of the 1930-40 era was an evolutionary warship emerging from the experience gained in battlecruiser and battleship design and operation from the period of 1905-22. The great stimulus, particularly for the British and French battleships discussed in this text, was the 1922 Washington Treaty limitation on displacement and armament tempered by naval battles fought in World War I—the Battle of Jutland being the most significant. Generally, the modern battleship combined high speed with increased gun power and protection. The first ships were affected somewhat by the Washington Treaty limitations, but more importantly by fiscal and industrial priorities. Despite artificially imposed treaty limitations,* the modern battleship evolved into a massive ship combining a 30-knot speed with considerable offensive power and the ability to sustain heavy punishment. The primary goal was to design a ship able to take damage, yet still be able to deliver a decisive blow to an opponent. Such requirements forced considerable growth in the physical dimensions and displacements of Allied capital ships as compared to those built in the same period before World War I. Only the Soviet Union was not limited by the treaties, and as a result her capital ships were considerably larger than those of most other countries that were building battleships or battlecruisers.

By the end of World War I, the fast-battleship concept had been accepted by all major naval powers except the United States. In fact, France, Italy, and the United States were the only major naval powers not possessing battlecruisers. Japan, Italy, Germany, Russia, and Great Britain were all constructing ships that could be reasonably termed fast battleships. Although few of these ships were completed, they established the trend for the next major naval building epoch, two decades later, when improved technology facilitated the construction of well-protected fast battleships.

* Washington Conference (1921-22), London Naval Conference (1930), and the Second London Naval Conference (1935-36). The 1927 Geneva Disarmament Conference resulted in no limitations on capital ships, but did result in British efforts to reduce the gun size and battleship displacement from 1927-35. For all practical purposes, all treaty limitations expired on 31 December 1936.

The U.S. Navy's Michigan was completed after the Dreadnought, although her design antedated that of the British battleship. The all-centerline arrangement of the main battery, with superfiring turrets, was a much superior configuration.

Washington Naval Treaty. At the end of World War I, the U.S. Navy was well started on an all-out expansion program so extensive that it threatened the traditional supremacy of the Royal Navy. The American naval expansion program also threatened the new position of power that Japan had established in the Pacific, causing her also to embark on a fleet construction program (8-8 fleet).^{*} Because of these two developments, the British initiated new capital-ship design projects during 1920-21. These ships would have been the most advanced and powerful ships of that period and would have prompted further response from the United States and Japan. Four battlecruisers and four battleships were projected with the particulars tabulated below:

TABLE 1-1

Proposed 1921 British Capital Ships

	<i>Battlecruiser (G-3)</i>	<i>Battleship (N3)</i>
Full-load displacement	53,900 tons (54,800 mt)	48,500 tons (49,300 mt)
Waterline length	850 feet (259 m)	815 feet (248.4 m)
Waterline beam	106 feet (32.3 m)	106 feet (32.3 m)
Draft	35.7 feet (10.9 m)	33.0 feet (10.1 m)
Shaft horsepower	160,000 (162,200 mhp)	50,000 (50,700 mhp) [*]
Speed	31 knots	23.5 knots
Armament	nine 16"(406-mm)/45 3-3-A-3-A† sixteen 6"(152-mm)/50 in twin mounts	nine 18"(457-mm)/45 3-3-A-3-A† sixteen 6"(152-mm)/50 in twin mounts

^{*}Authors' estimate

† "A" in this text refers to superstructure.

Finally, because of the enormous financial strains imposed by the huge naval expansion programs under way in the United States, Great Britain, and Japan, the United States proposed a naval disarmament conference. This invitation was immediately accepted by the British government and soon after by Japan, Italy, and France. On 12 November 1921, representatives of the major naval powers met in Washington, D.C., for the Washington Naval Conference, which produced a naval agreement that would have a profound effect on future Allied battleship design.

It is worthwhile to note those provisions of the Washington Naval Treaty, signed on 6 February 1922, which influenced capital-ship design:

- British and American fleets were limited to 580,450 and 500,360 tons respectively, with Japan at 60 percent of U.S. strength (301,320 tons), France at 221,170 tons, and Italy at 182,000 tons. (This was the famous "5-5-3 ratio" so bitterly resented by the Japanese.) All displacements were in tons of 2,240 pounds (1,016.05 kilograms)†, and the comparative displacements were calculated on the basis of the "standard" displacement defined later.

^{*} The 8-8 Fleet Program featured the construction of eight fast battleships and eight battlecruisers.

† Metric-English Measurements. The comparison of characteristics of ships built by different nations has long been complicated by the use of diverse measurement systems. In this text measurements for all ships are in the system employed by the country that built them; all tabular data are presented in both metric and English measurement. This may at times result in too-precise values, where a general value in one system is converted to the other and the exact conversion is retained in order to best indicate the actual value under discussion. For convenience, armor thicknesses on plans are given in millimeters only. One mm = 0.03937.

- Capital ships were limited to 35,000 tons standard displacement, with 406-mm guns the largest permissible.
- Standard displacement was established as the displacement of the vessel complete, fully manned, equipped, and ready for sea, including ammunition, provisions, fresh water for her crew, and miscellaneous stores and implements of every description to be carried in war, but *not including* fuel or reserve feed water.

The displacement and armament restrictions made the introduction of efficient weight-saving techniques mandatory. Designers were forced to devise and develop new concepts and procedures, many of which later became fundamental when capital-ship construction was resumed before World War II. The Washington Naval Treaty, despite the ten-year naval "holiday" it enforced, altered the course of capital-ship design and exerted the most profound influence on battleship technology since the HMS *Dreadnought*.

The first "treaty" battleships. In view of the new Japanese and American battleships nearing completion, the Washington Naval Treaty permitted the Royal Navy to complete two battleships, the *Nelson* and the *Rodney*, which were laid down on 28 December 1922. (In addition, France and Italy were permitted the construction of new battleships not to exceed 70,000 tons total displacement, each, since both countries had been unable to complete new ships in the period of 1916-21.) The British had already completed the *Hood*; however, she had 15-inch guns, and the new battleships in Japan and America were ships armed with 16-inch. Although early designs called for 15-inch, the First Sea Lord ruled them out and called for a design featuring 16-inch. The British battleships were a novel type, because they were the first to be built under the restrictions of the treaty and as a result featured many innovations incorporated in later battleships. Essentially, they were modifications of the 1921 battlecruiser design (G3) with the full-load displacement reduced from 53,900 tons to 38,400 tons, waterline length reduced by 160 feet, and shaft horsepower slashed from 160,000 to 45,000. The arrangement of all three turrets forward gave the superstructure the appearance of having been pushed far aft of the conventional position. Armor protection was concentrated in the citadel, with a thick but still too shallow internal main side belt inclined from the vertical for increased effective thickness. This concentration left the forward portion of the hull and sides above the armor deck unprotected. Such efforts to save weight on armor protection were typical of all displacement-limited, modern battleship designs. In addition, the system of underwater protection was then unique in British battleships. Underwater explosion experiments had indicated that the type of underwater protection in the *Hood*, which featured crushing tubes in the bulge, was not as good as a system which had a liquid substituted. Such a system was less costly and more effective in a weight-limited ship. Particulars of these ships as completed are shown in Table 1-2.

Construction of the *Nelson* and *Rodney* afforded much valuable experience for future battleship construction. Accurate weight determination and weight saving were much more important than before. Standard fittings used earlier were redesigned to minimize weight, a new steel with improved yield strength ("D" steel) was employed in critical structural members, and joiner-dividing bulkheads were made of light-weight, fire-resistant plywood and aluminum. The secondary armament was arranged in turrets rather than in casemates and the upper citadel belt which enclosed these casemates was eliminated. The secondary turrets had light armor protection, sufficient against splinters, and this arrangement was to become a universal feature of the final generation of battleship design. All these efforts, including the internal slop-

TABLE 1-2

Particulars—Nelson and Rodney

Standard displacement	33,313 tons (33,850 mt) (<i>NELSON</i>)
Full-load displacement	37,800 tons (38,400 mt) (<i>NELSON</i>)
Waterline length	700 feet (213.4 m)
Waterline beam	106 feet (32.3 m)
Draft	29.75 feet (9.07 m)
Shaft horsepower	45,000 (45,600 mhp)
Speed	22 knots
Armament	nine 16"(406-mm)/45—tripled disposition: 3-3-3-A twelve 6"(152-mm)/50—twins six 4.7"(120-mm) twelve 3 pounders eight Pom-poms nineteen machine guns
Main side belt*	two 24.5"(622-mm) torpedo tubes (underwater) 14"(356-mm)—magazines 13"(330-mm)—machinery
Deck	6.25"(159-mm)—magazines 3.75"(101-mm)—machinery
Underwater	750-pound (340-kg) torpedo warhead in contact with shell at half draft.

* The main side belt was inclined at 18°.

ing of the main side belt, brought the ships under the 35,000-ton limit by more than 1,500 tons, a helpful margin for later modernizations.

Although the *Nelson* and *Rodney* had many features that would be used in foreign battleships of the 1930s, they were not auspicious heralds of the coming era of the modern battleship. They had a very slow speed and their new 16-inch guns proved to have severe bore-erosion problems, forcing the acceptance of a reduced muzzle velocity which substantially downgraded the performance of the guns. The new turrets had a number of mechanical problems, which were gradually corrected during the early years of operational service. More importantly, salvo fire was limited during peacetime service because of blast-damage problems, and the superstructure severely limited the arcs of fire of the main-battery turrets. In fact, comparing these guns with the very successful 15-inch guns of earlier British battleships shows that the 16-inch guns of the *Nelson* and *Rodney*, with the reduced muzzle velocity, were decidedly inferior. The ships had the reputation of handling badly, and conning was difficult because the bridge was so far aft. The maximum speed was 22 knots, no faster than many pretreaty battleships. At best, the *Nelson* and *Rodney* were only limited successes. Nevertheless, many of the new battleship designs that followed them often included a *Nelson*-style arrangement of the main battery, and in the case of the French Navy resulted in the adoption of an arrangement of all main-battery guns forward in the *Dunkerque* and *Richelieu*-class capital ships.

The London Naval Conferences. After the unsuccessful 1927 Disarmament Conference in Geneva, the prospects for further limitation on battleship size seemed doubtful. Nonetheless, the Admiralty decided to investigate smaller battleship designs, which later brought about a policy of trying to convince other naval powers to build a 25,000-ton ship armed with 12-inch guns. This policy manifested itself after the election of a new British government under Prime Minister Ramsay MacDonald, who called for a new conference in London to reach an agreement on further naval limitations. When this conference concluded its work, there were no further limitations

on capital-ship design, although Great Britain did formally accept the right of the United States to possess a fleet equal to that of the Royal Navy. This was significant, because it heralded greater British and American cooperation in the future. The "holiday" in capital-ship construction was extended to 31 December 1936, and it was agreed that another naval limitation conference should be convened in 1935.

The London Naval Conference of 1935-36 resulted in the 1936 London Treaty, which was signed by Great Britain, France, and the United States in March. The treaty reaffirmed the 35,000-ton standard displacement limitation of the earlier treaties, but the main battery was further limited to 14-inch. As the Japanese officially had withdrawn from the conference, the treaty stipulated that the gun-caliber limit would revert to 16-inch if the Japanese failed to ratify the treaty by 1 April 1937. If any navy built ships exceeding the treaty limits, signatories to the treaty were given the right of escalation to a new standard displacement limit of 45,000 tons. Also significant was the fact that Italy and Japan were not signatories of this agreement, but they did send observers to the conference. German observers were also present, but they did not sign the document, since the Anglo-German Naval Treaty of 1935 required Germany to observe all naval treaties that had been previously, or were subsequently, concluded.

7

Post-World War I capital-ship construction. When Germany began the construction of her armored ships, France authorized the construction of the battlecruiser *Dunkerque* in 1931 and the race was on again. Within a few years, capital-ship construction programs were active in all major navies. The new ships, with the exception of several best defined as battlecruisers, all displaced at least 35,000 tons, and had a powerful armament, good protection, and maximum speeds of at least 27 knots. The heavy gun was still considered the most effective naval weapon, although aircraft and submarines had advocates who insisted on claiming their supremacy. Naval authorities in Japan, Germany, Italy, Russia, France, the United Kingdom, and the United States showed their confidence in modern battleships by starting to construct powerful new ships with the best attainable combination of armor, long-range guns, improved anti-aircraft batteries, good speed, and extensive subdivision and compartmentation.

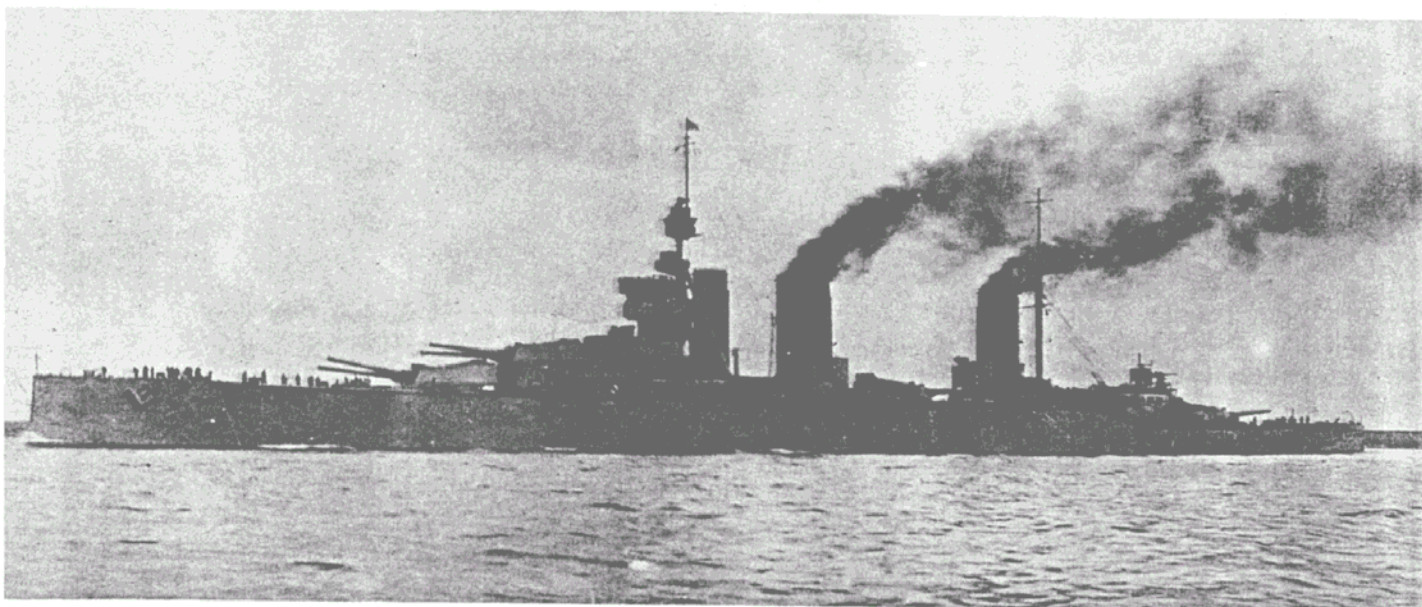
The new ships represented the culmination of a long trend in capital-ship design by merging the speed of the battlecruiser with the gun power and protection of the battleship. The new, fast battleships approached the characteristics of the ideal battlecruiser as first proposed in 1905 by William Hovgaard.* Despite the high speed, technological advances permitted the incorporation of improved protection and more powerful guns in the new capital ships, which had these tactical and strategic characteristics:

- Higher maximum and cruising speeds, which improved mobility and gave added flexibility to the battle fleet.
- Larger and more powerful guns, concentrating greater relative power in a single ship.
- Better gun-platform stability and considerably improved gunfire-control systems. The wartime incorporation of radar systems accentuated the contrast.
- Greater displacement, contributing to the ability to absorb more punishment.
- Great cost and large crews, which combined to make the loss of such ships tantamount to a national disaster.

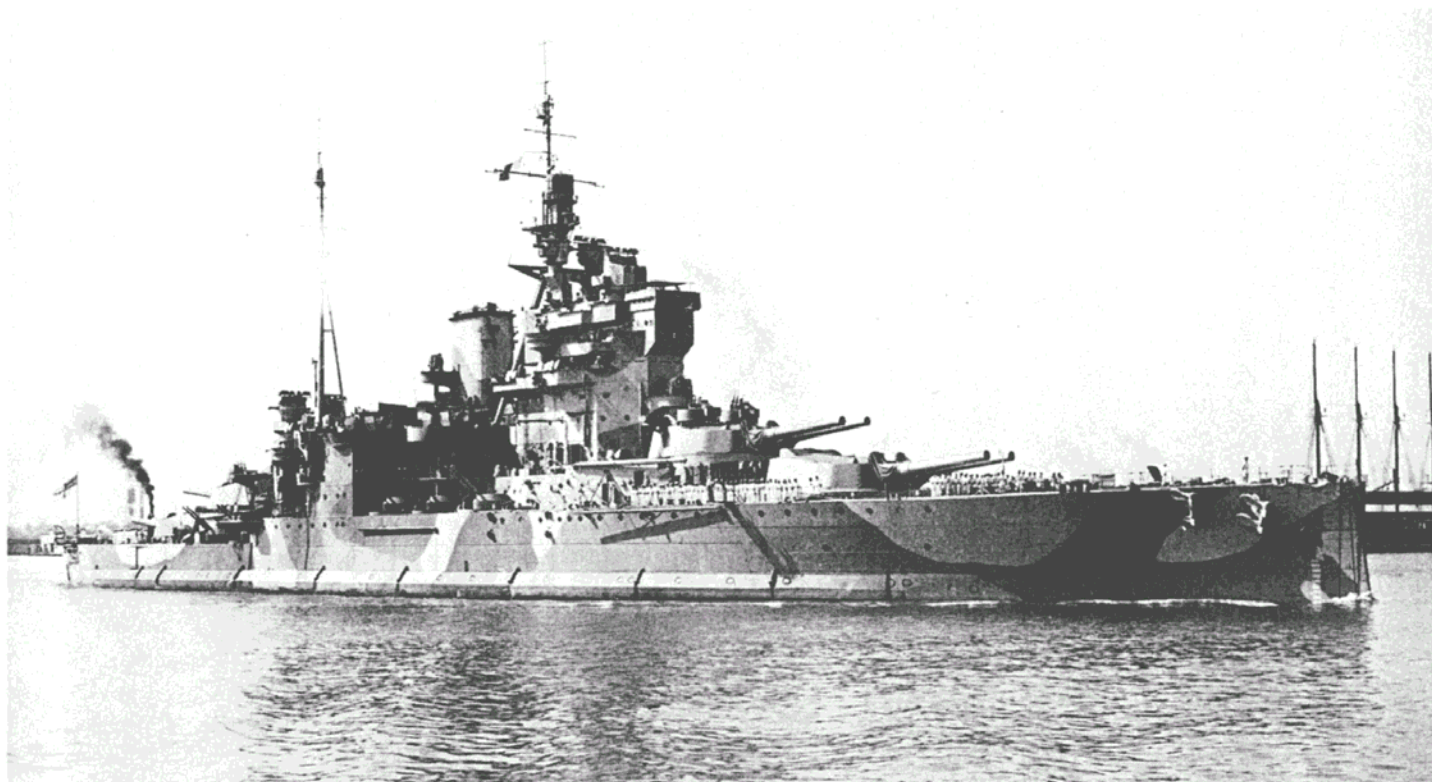
* *Transactions of the Society of Naval Architects and Marine Engineers*, 1905 edition, New York, N.Y.



The Royal Navy's Dreadnought, completed in 1906, revolutionized naval warfare by clearly out-classing all earlier battleships. The Dreadnought gave her name to the new type of battleship, of which she was the first. Earlier type battleships were henceforth called pre-dreadnoughts. (Imperial War Museum)



The Lion was a typical World War I battlecruiser, with relatively high speed attained at the expense of good protection. The Royal Navy's concept of the type was shown to be disastrously vulnerable during the Battle of Jutland. Similar German ships featured better protection, lower speed, and a smaller caliber main battery; they proved to be superb warships that helped point the way to the true fast battleships of the World War II era.



The battleships of the Queen Elizabeth class were the finest capital ships of the World War I era, with an outstanding combination of good speed, powerful armament, and good protection. The Queen Elizabeth is shown (top) in her original configuration. The bottom view shows her in June 1943. She now has a much more massive superstructure, antitorpedo bulges, a single-trunked funnel, dual-purpose guns, and numerous anti-aircraft machine guns. (Imperial War Museum and U.S. Navy)

The preceding discussion covers general trends in capital-ship design. There follows a discussion of the more technical aspects of ship characteristics and design necessary to full appreciation of the various ships described in this study.

Armament. Two basic developments led to the most apparent differences between battleships and battlecruisers of the World War I era and later capital ships: the newer ships had more powerful main-battery guns* with greater maximum ranges (largely the result of increased maximum elevation limits in turrets) capable of penetrating heavier armor at given firing ranges, and their increased anti-aircraft batteries emphasized the growing threat of air power that would eventually make the battleship obsolescent.

Improvements in heavy naval guns were largely evolutionary in nature, but the cumulative effect was of major consequence. Generally, newer guns fired much heavier projectiles than earlier weapons of the same caliber. Muzzle velocities were often less than for similar earlier weapons; this reduced bore erosion noticeably. Improved turret designs increased maximum elevation, thereby considerably increasing range, while the heavier projectiles gave better armor penetration.

Turrets. Twin turrets were used in the majority of European World War I capital ships, although several classes carried triple turrets, and the French *Normandie*-class battleships were designed to mount quadruple turrets. For ships designed after the naval "holiday," the treaty displacement limitations, coupled with the pressures for higher speed and improved horizontal and underwater protection, led to the selection of quadruple turrets for the British *King George V*-class, and the French battlecruisers of the *Dunkerque* class and the battleships of the *Richelieu* class. The quad turrets helped to minimize the necessary length of the armored citadel while permitting more guns in the main battery for less weight per gun. With the particularly stringent displacement limits on the French battlecruiser design, even the secondary armament of 130-mm guns on the *Dunkerque*-class ships featured quadruple turrets.

German rejection of the triple turret in the *Bismarck*, despite its success in the *Scharnhorst* and *Gneisenau*, emphasized a widely held conviction that twin turrets permitted more effective gunnery with greater dispersion of the main battery and relatively little added displacement. All later German battleships had twin turrets, despite the almost universal adoption of triple or quadruple turrets in other navies. The British battleship *Vanguard* mounted obsolescent 15-inch guns in twin turrets held in reserve for older World War I battleships, but she represented a design and material compromise accepted in an effort to expedite the completion of a battleship before the originally projected 1944 completion date of the first *Lion*-class ship.

The relative power of heavy guns of similar vintage was generally proportional to their bores, with some exceptions. The U.S. *Iowa*-class ships mounted 16-inch guns that were superb weapons for that caliber, while the Japanese *Yamato* and *Musashi* mounted 18.1-inch guns that were at best of mediocre quality. As a result, for similar battle ranges the penetrative capabilities of the two guns were essentially equal. This is a classic example of the difficulties inherent in comparing the attributes of different classes of capital ships.

Cartridge and bag ammunition. Although powder charges for smaller caliber guns had long been contained in metallic cartridges, the use of such cartridges for heavy

* See Appendix C for data on these guns.

naval guns was not widespread. The German and Austro-Hungarian Navies had pioneered the use of such heavy cartridges before World War I.

In certain respects, the cartridge has considerable advantage. A magazine loaded with powder charges in cartridges instead of in bags in lightweight canisters is much less likely to receive disabling damage from a shell hit. In addition, the cartridge contributes to the sealing of the breech opening, thus making possible the adoption of a sliding wedge-type mechanism, improving the potential for higher rates of fire. When cartridges are used, there is much less likelihood of flareback-type disasters caused by smoldering remnants from a previous powder charge.

On the other hand, cartridges for heavy guns are, of necessity, heavy and awkward to handle, forcing the adoption of complicated handling equipment if the potentialities of higher rates of fire offered by the simplified breech mechanism are to be realized. Bag ammunition is normally segmented, thus permitting the handling equipment to be much less heavy and complicated. Despite having had two years after the end of World War I to examine the *Baden*, one of the most modern German dreadnoughts, the Royal Navy declined the opportunity to follow the German example when the development of the 14-inch guns for the *King George V* began in 1935. It should be noted that the British favored the forged steel slide and hydraulic power for their heavy mountings.

11

Dual-purpose guns. The United States, Great Britain, France, and Japan developed new dual-purpose guns effective against either light surface ships or aircraft. They believed that there was no need for a separate antiaircraft battery. A dual-purpose gun was selected with the intention of providing sufficient performance to engage either air or surface targets. Control was normally arranged to split the battery for antisurface and antiaircraft purposes, with the important advantage that *all* the secondary battery would be available to either air or surface attack.

The Germans and Italians, on the other hand, had not developed such dual-purpose guns and preferred to use mixed-caliber secondary batteries. These navies considered the repulse of the fast-moving destroyer as the vital concern to the capital ship. Despite expense, weight, erosion, and other objections, they advocated the gun with the flattest possible trajectory and the best possible position for resisting destroyer attacks. It was believed that the antiaircraft armament could have a shorter range. The Russians, with tremendous design assistance from the Italians, followed the same philosophy.

The merits of the dual-purpose battery, as compared to the mixed-caliber battery, can be debated at length. Briefly, the former permitted a more numerous single-caliber battery that would in all likelihood never be needed to engage surface and air targets simultaneously. Dual-purpose mounts were relatively economical in weight and space, while mixed-caliber batteries of necessity required greater space and weight, yet provided fewer barrels to engage either surface or air targets. On the other hand, proponents of the mixed-caliber battery argued that the necessity of a high rate of fire limited dual-purpose batteries to a bore too small to be effective against cruisers and destroyers. Normally, heavier guns in the mixed battery were about 150 mm, with dual-purpose being 127-134 mm. The point was a valid one if, in fact, surface ships of cruiser and destroyer size were encountered. This was a case where there was no "right" answer—the key was the operational employment of the ships under discussion. For example, the French *Richelieu*-class battleships were armed with a mixed-caliber battery of 152-mm and 100-mm guns, both of which had dual-purpose capabilities. In service, the 152-mm guns were found to be of limited effectiveness in antiaircraft engagements.

In any event, the heavy antiaircraft fire of such ships generally was sufficient, although more guns would have been desirable. Under World War II combat conditions, however, prewar conceptions of the need for machine-gun batteries proved to be hopelessly inadequate.

Antiaircraft machine guns. Typically, at the outbreak of World War II a capital ship had perhaps two dozen antiaircraft machine guns of two or three calibers. By the end of the war it was common for such ships to carry as many as a hundred of these machine guns.

These light machine guns were to provide close-in (less than 10,000 yards) coverage with a large volume of fire. During the interwar period, Great Britain led the way in the development of a suitable shipboard antiaircraft machine gun. In 1926 Vickers began development of the pom-pom machine gun mount. This multi-barreled mount would be capable of rapid and accurate fire against aircraft within 5,000 yards. Unfortunately this weapon could not keep pace with the rapid advances in aircraft technology, and by the time World War II began this gun mount was almost obsolete. At first, the .50-caliber machine gun was considered a good weapon against strafing planes, but the development of the 20-mm Oerlikon gun at the beginning of World War II and the increase in speed and maneuverability of aircraft saw the 20-mm gun replace the .50-caliber machine gun in all combatant ships. In 1939, the typical machine-gun armament of a French or Russian battleship was 37-mm guns and .50-caliber machine guns, while British battleships included the .50-caliber machine gun with the short-barreled 40-mm pom-pom mounts. As the war continued, it became evident that the pom-pom and the 37-mm gun were ineffective, and they were replaced with the more efficient 40-mm Bofors. The postwar reconstruction of the French battleship *Jean Bart*, with her antiaircraft armament of 100-mm and 57-mm guns, reflected the lessons learned during World War II Pacific actions.

Two primary concerns in the placement of the light battery were the problem of providing complete hemispherical coverage of the ship and eliminating the blast interference of the main and secondary guns. The latter was an extremely difficult problem to avoid. Ready service ammunition stowage for machine guns was an equally acute problem. In general, these problems intensified because, as the war continued, the air threat became worse, and additional guns were installed as weight and space permitted. It was not uncommon for 40-mm mounts to be placed on top of main-battery turrets of French or British battleships by the end of World War II.

Gunfire control and radar. Of equal importance to the improved ballistic properties of guns was the improvement in fire-control equipment. Even before the advent of radar, such progress had been made that one naval authority commented:

By the early 1930s, battleships were demonstrating their ability to fire effectively 14- and 16-inch projectiles at unseen, maneuvering targets at ranges greater than 15 miles in salvos of from 8 to 12 guns, remotely controlled and fired from a single key. . . .

The Royal Navy pioneered in the service introduction of radar for search and fire control. Although radar systems were quite primitive at the time of the *Bismarck* chase in May of 1941, the British use of radar played an important role in the destruction of the German battleship. Radar and mechanical analog fire-control computers substantially increased the effective ranges of naval guns against both surface and air targets, while permitting for the first time accurate engagement of targets otherwise obscured by darkness, fog, or smoke.

The proliferation of antiaircraft batteries and the increasing complexity and sophistication of gunfire-control systems contributed to the inexorable growth in

topside clutter on modern capital ships. In addition to various search-radar installations, a typical *King George V*-class battleship had two main-battery fire-control directors, one forward and one aft, plus four secondary battery directors, two on either beam. In the *HMS Vanguard*, directors were also provided for the 40-mm batteries. All this equipment, of course, contributed greatly to gunnery accuracy, but it also made the ships more vulnerable to damage to key gunfire-control systems.

Antiaircraft VT Fuzes. In addition, the development of the proximity or VT (variable time) fuze for antiaircraft guns considerably increased their chances of a "kill," as a direct hit was not longer necessary to damage an aircraft. The mechanical time fuze was used throughout the war, but the VT fuze represented a vast improvement in antiaircraft defense. VT fuzes were fitted to the Royal Navy's 5.25-inch antiaircraft shells during the course of the war, vastly improving the antiaircraft effectiveness of the British 5.25-inch/50 caliber dual-purpose gun.

13

Torpedoes. Although no capital ships completed during World War II had torpedo tubes installed, owing to weight and space difficulties and the risk of severe damage resulting from hits in the vicinity of the tubes, several German ships were fitted after their completion with deck-mounted tubes for use in commerce-raiding. Early Royal Navy design studies of the *King George V* and *Lion* classes provided for torpedo armament, a reflection of the lessons of Jutland and preradar operational expectations of occasional close-range engagements in conditions of poor visibility.

The development of radar systems contributed substantially to the decline of the surface ship as a factor in commerce raiding, and also led to the abandonment of Royal Navy projects for torpedo armament of capital ships. From the standpoint of battle-damage resistance, the elimination of torpedo tubes from capital ships was a highly desirable development.

Armor Protection. Battleship armor protection, traditionally, was designed to withstand attack by guns equal in caliber to those carried in the main battery. Battlecruisers were given protection on the basis of widely varying standards, ranging from essentially a battleship scale of protection down to the requirement that the citadel be able to withstand shellfire from heavy cruisers.

Early in the dreadnought era, side armor thickness was the primary index of adequate protection, because the relatively close ranges anticipated in combat made the likelihood of shells hitting the deck negligible. As ordnance refinements increased effective gun ranges, there was a growing awareness of the need to provide deck-armor systems. Eventually the concept of the immunity zone as a criterion for the adequacy of the armor suit of a ship was widely accepted.

The immunity (or protected) zone is a range band for a specified gun in which the armored portions of the target ship were designed to resist penetration by a designated projectile. At or below the lower range limit of the zone, side or vertical armor would be penetrated, while at or above the upper limit, deck or horizontal armor would be penetrated. These range limits are normally determined for a ship floating upright (no roll, pitch, trim, or list) with a specified target angle, usually 90 degrees. Under actual conditions in a seaway, the likelihood of roll, pitch, and yaw complicates the calculation of the real immunity zone. Inevitable variations in armor and projectile quality as well as ballistic performance introduce further uncertainties. As a result, the most prudent tactical maneuver was to maintain position near the center of the calculated immunity zone.

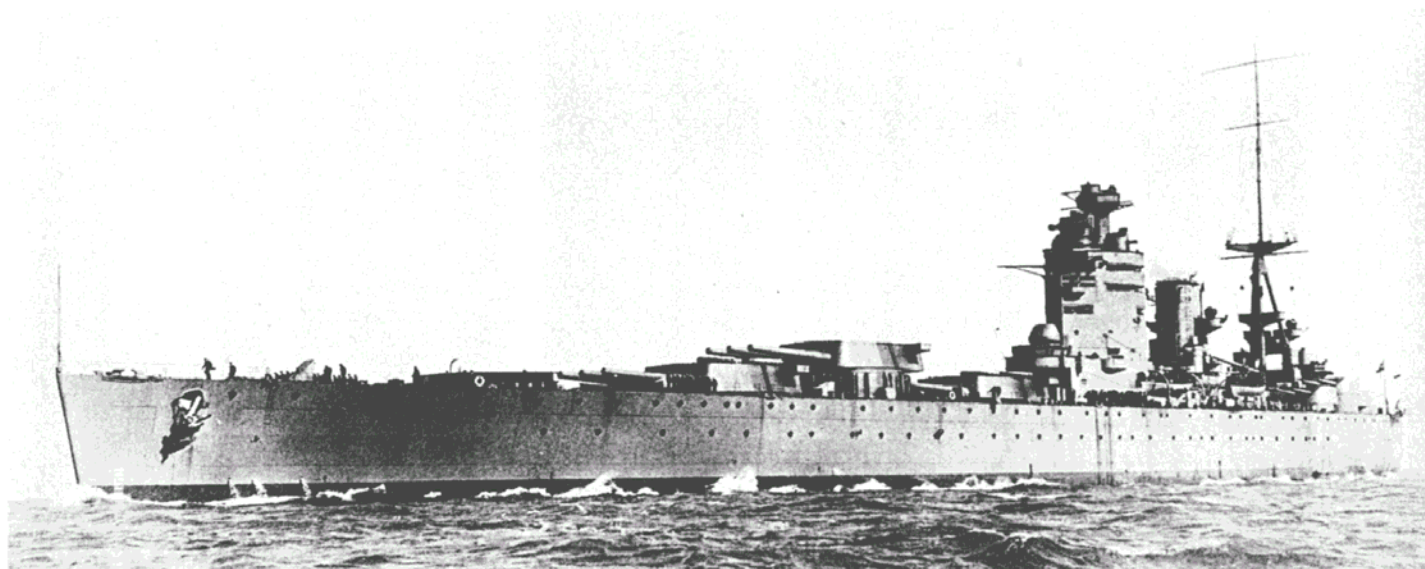
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The Ramillies was one of five "R"-class ships contemporary to the Queen Elizabeth. Their inferior speed and lighter horizontal protection made them decidedly less valuable for World War II operations.

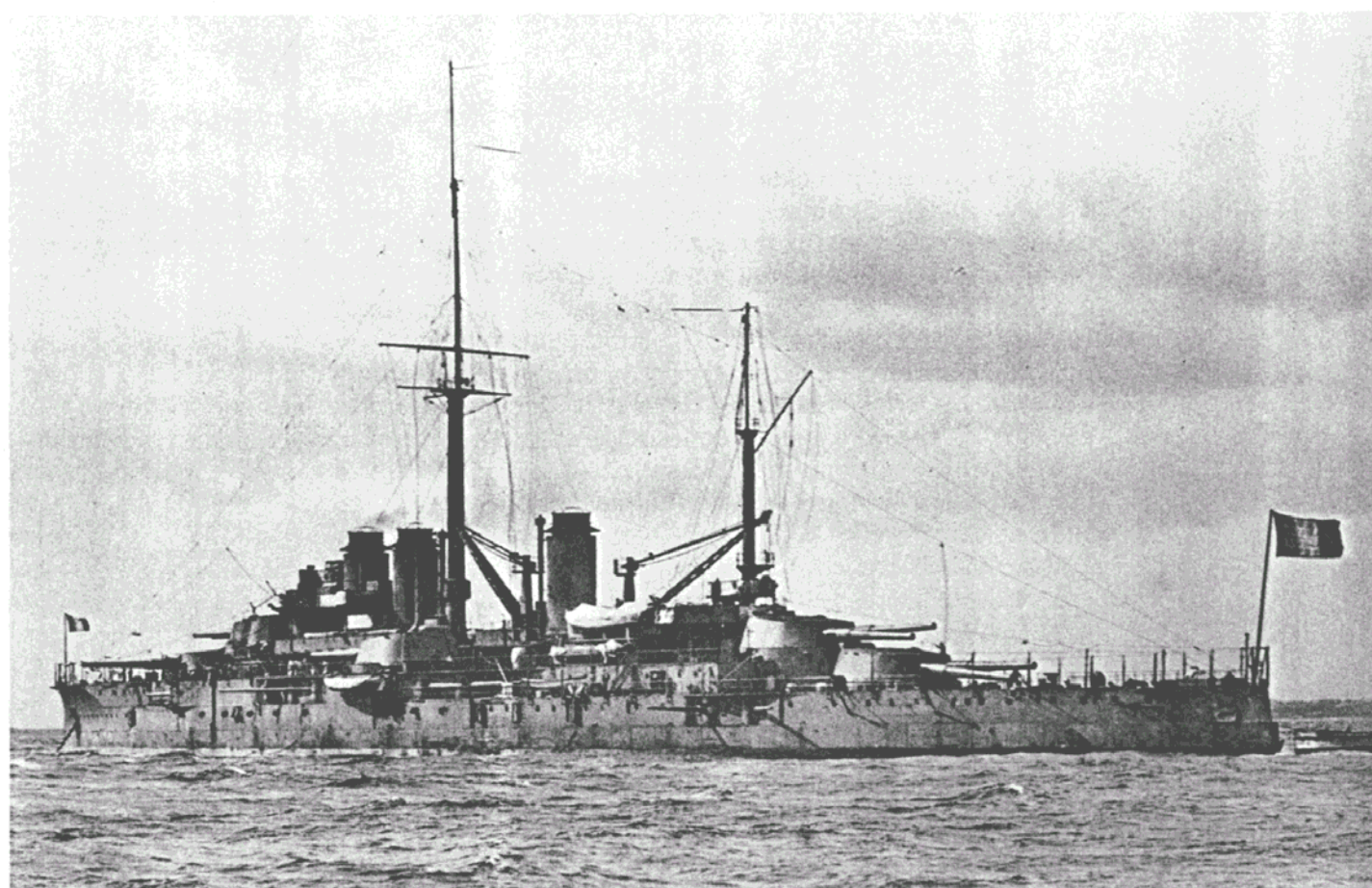


The Nelson in January 1945, nearing the end of her second decade of active service. Note the added topside clutter caused by the proliferation of antiaircraft machine-gun batteries and the addition of radar.



15

The Royal Navy's Nelson and Rodney were the first battleships built from the keel up under the terms of the Washington Naval Treaty. This view shows the Rodney shortly after her commissioning in 1927.



The Courbet, completed in 1913, was one of the first four French dreadnoughts. Note the amidship wing turret, which was typical of many of the early dreadnoughts. The main battery was twelve 305-mm guns in six twin turrets.

Calculations of potential side armor penetration are critically affected by the target angle. This target angle is the angle formed between the gun-target line and the centerline of the target ship, measured in the horizontal plane. For optimum penetration, this angle is 90 degrees. Obviously, this target angle has no effect on the penetration of horizontal armor.

It is important to remember that a 90-degree target angle does *not* mean that the projectile will strike vertical side armor perpendicular to its surface. The angle of impact of the projectile is dictated by a combination of the target angle, the angle of fall of the shell, and the inclination of the armor plate from the vertical. As optimum armor penetration results from a normal impact angle, warship designers often attempted to enhance the tendency of projectiles to ricochet by inclining the armor from the vertical (top edge farther outboard), thereby enhancing the effective thickness of the armor.

The concept of the immunity zone gave the capital-ship designer a useful analytical device for evaluating the most efficient way to improve armor protection. The greater the net width of the immunity zone, the greater the tactical flexibility of the ship. By calculating the added weight of improved armor protection, and comparing this with the change in width of the immunity zone for each variation in protection, the designer can select the more efficient way of improving the width of the immunity zone.

For example, assuming a ship has a theoretical immunity zone of 18,300 to 27,400 meters against the American 356-mm/50-caliber gun, it is decided to evaluate the effect of adding ninety-eight tons of armor protection. Over the relatively great area of the deck armor, this is equivalent to a modest increase in thickness, which adds 270 meters to the necessary firing range for penetration. (Remember—long-range plunging fire obtains added deck armor penetrative capability as range is increased.) Applying the same weight to side armor, a somewhat greater thickness increase is possible, corresponding to a reduced firing range for side armor penetration of 460 meters. In this instance, improving the side armor protection is clearly the most effective way of improving the width of the immunity zone.

Unfortunately, life is never quite so simple. Such analyses as that presented above ignore the relative probability of the side of the ship being hit compared with the likelihood of the deck being struck. As improved technology made long-range gunnery engagements ever more likely, the relative probability of the deck armor system being hit increased tremendously, lessening the importance of heavy side armor systems.

As in many instances of warship design, the designer is forced to a difficult compromise between contradictory requirements.

Belt armor. Prior to the dreadnought era, belt armor had been fixed vertically on the exterior sides of the hull. A few capital ships at the end of World War I were completed with inclined armor systems in an effort to improve the armor resistance by increasing the tendency of projectiles to ricochet harmlessly from the inclined armor. A projectile striking an armor plate obliquely meets a greater thickness of armor, but the effective thickness of the plate increases well beyond this factor. For example, a plate inclined 15 degrees from the vertical provided resistance equivalent to that of a vertical plate of some 30 percent greater thickness. On the other hand, a projectile approaching an inclined armor plate obliquely meets a smaller target width than if the plate were vertical. The inclined armor system must be wider to present the same effective area to an oncoming projectile. The ballistic data in Table 1-3 refers to the 380-mm guns carried by the *Richelieu* and *Jean Bart*.

At a firing range of 22,000 meters, an inclined plate (15 degrees from the vertical) provides the resistance of a vertical plate of 30 percent greater thickness, yet must be

TABLE 1-3

The Effect of Projectile Angle of Fall on Required Plating Width for Inclined Side Armor

Range (meters)	Angle of Fall	Vertical Plate* Target Width	Inclined Plate (15°) Comparable Width†
22,000	19°20'	9.44	11.43(+14.3%)
27,000	26°50'	8.94	11.90(+19.0%)
35,000	40°25'	7.62	13.39(+33.9%)

* Vertical plate width, 10 meters.

† Necessary inclined plate width, to provide equal target width to that provided by 10-meter vertical plate.

only about 14 percent larger than a vertical plate of comparable effective area. For similar resistance, the inclined plate saves about 10 percent of the weight required by a vertical belt system. As the firing range increases, the inclined plate gradually loses its advantage, but it was the closer ranges that were of importance to designers. At longer ranges, the horizontal protection is much more likely to be hit than the side protection.

The thick armor belt was carried a few meters below the design waterline, because shell damage became less probable and such massive weight could not be tolerated in weight-limited designs. Also, damage to main side belts in World War I and tests during the interwar years showed that shell hits below the waterline from projectiles with underwater trajectories resulted in more flooding and limited structural damage rather than the penetrative type of damage. Frequently, plates were set back by the impact of a heavy projectile, causing the structural backing and hull plating below the bottom edge of the armor to open up. A remedy adopted in almost all the later battleships was to provide a thin armor belt or armored torpedo bulkhead (in those ships with vertical armor on the sides) below the main side belt. Projectiles with underwater trajectories would be sufficiently slowed so that armor of 45-80-mm thickness would provide adequate protection. The structural backing to this bulkhead was important, and in French, American, and German battleships, welded construction was used to increase the resistance to leakage.

Great Britain and Germany were the only countries that equipped their new capital ships of the World War II era with vertical armor protection on the exterior of the ship. Although this system weighed more than the inclined type for similar protection, it kept shells from damaging the outer plating, causing flooding of wing compartments, and reducing transverse stability. The *King George V* design was most notable, because it did not follow the sloping armor system of the *Nelson* and *Rodney*. The advantages of the vertical armor system, however, were considered to outweigh the sloping type, particularly in view of the fact that a diving shell would be deflected downward into the bilge compartments, seriously reducing buoyancy and causing a large listing moment.

Horizontal protection. The usual scheme of horizontal armor protection in pre-1930 battleships consisted of a single deck of sufficient thickness to defeat a projectile at a specified range. In some instances (France, the United States, and Netherlands), a splinter deck was added one deck below. By 1935 it was believed that the heavy deck, known as the "protective" or "armor" deck, should be positioned two to three decks below the weather deck (space between decks = 2.5-2.75 meters). This meant that the armor deck would be some five to eight meters below nonballistic material. To raise the armor deck involved the addition of more side belt armor and an increase in weight.

plus the adverse effect on the vertical center of gravity, which made it impossible to locate this deck any higher. By 1935, the airplane had become an important factor in naval warfare—particularly in attacks with armor-piercing bombs—and it was assumed that accurate level bombing would eventually be possible from heights beyond antiaircraft gun ranges, and that the development of accurate bomb sights would improve the accuracy of bombing from high altitudes.

Based upon these considerations, it was felt wise to use a light armor deck (at the weather-deck level) of 40-50 mm of special treatment steel (STS)* that would be capable of defeating lightcase demolition bombs. Armor-piercing bombs would penetrate it, but since this deck was at least five meters above the main armor deck, the armor-piercing bomb, in theory, would be brought to explosion at the level of the main armor deck. Fuze action would be initiated as the bomb passed through the upper armor deck. Later, during World War II, larger bombs with more explosive filler were developed with even greater fuze delays. The armor protection of a modern battleship was quite effective against conventional bombs of 100-1,000 kilograms, however. But as bomb sizes grew in World War II, thicker armor decks were required. A 1944 German battleship design study stipulated 350 mm of deck armor, as compared to 176 mm of armor on the *Bismarck*, completed only a few years earlier. Such massive protection could only be provided in giant ships, and the full-load displacement planned for "H-44" was 141,500 tons as compared to 50,900 tons for the *Bismarck*.

Aircraft bombs evolved into the most important factor affecting the design of deck-armor systems, as the progressively greater lifting capability of modern aircraft permitted the introduction of heavier and more powerful bombs. Several factors influenced the penetrative performance of aerial bombs:

- Altitude of release
- Plane speed and angle of dive (if any)
- Weight of bomb
- Ballistic properties of the bomb
- Angle of impact and striking velocity
- Structural adequacy of the bomb

The rapid increase in the required deck-armor protection made the problem insoluble. The only ships that could carry such massive armor systems would have to be prohibitively large. Modern aircraft with heavy armor-piercing bombs could defeat any practical armor system. Despite this, aircraft more frequently employed semi-armor-piercing or high-explosive bombs, in order to take advantage of the substantial possibility of major underwater damage caused by near-miss bombs with heavy explosive charges.

Similarly, although to a somewhat lesser degree, refined fire-control systems greatly increased the chance of long-range shellfire penetrating the deck armor. The possible penetration of deck armor increases with the range, as the more nearly perpendicular impact angle of the long-range shell is coupled with increasing striking velocities because of the effects of gravity. At very long ranges, the striking velocity actually *increases* as range increases.

* *Special Treatment Steel*—Relatively tough and ductile, suited for structural as well as ballistic protection applications. STS can be shaped relatively readily. Most horizontal armor systems were made of this steel. Maximum thicknesses were about 130 mm. Resistance was provided through the toughness and ductility of the steel, combined with the tendency of projectiles to ricochet. STS remains an important factor in warship construction.

The effect of modern ordnance technology on battleship design was the widespread acceptance of the "all-or-nothing" concept of protection, with the heaviest possible protection concentrated over the most essential areas, and the remainder of the hull and superstructure being essentially unprotected. Whatever the details of the armor arrangement, it was evident that much of the ship would remain vulnerable.

Conning towers. Armor protection of conning towers followed two courses in modern battleship design. The main-battery director systems of World War I-type battleships and battlecruisers had a high degree of protection, and their operators were located behind heavy armor. A considerable number of optical rangefinders were provided, any one of which could control the main battery. With the advent of heavy antiaircraft batteries, this system of rangefinders was extended to control these guns, whether they were of the dual-purpose type or single purpose. This led to the need for larger plotting rooms and more computing elements. It was important, however, to provide protection for the additional personnel, and placing them within the armored citadel would provide the advantage of increased protection. It also offered the highly desirable feature of removing the greater part of control personnel from blast interference which could be so great as to be almost demoralizing when both main and secondary guns were firing. This type of arrangement would have decreased top weights, including the weight of a heavy conning tower and other splinter protection aloft. This system was adopted in the Royal Navy in its pre-World War II battleships, but not in other contemporaries. All other navies opted for the heavy, armored conning tower, but some of the plotting and computation spaces were moved below to the armor box.

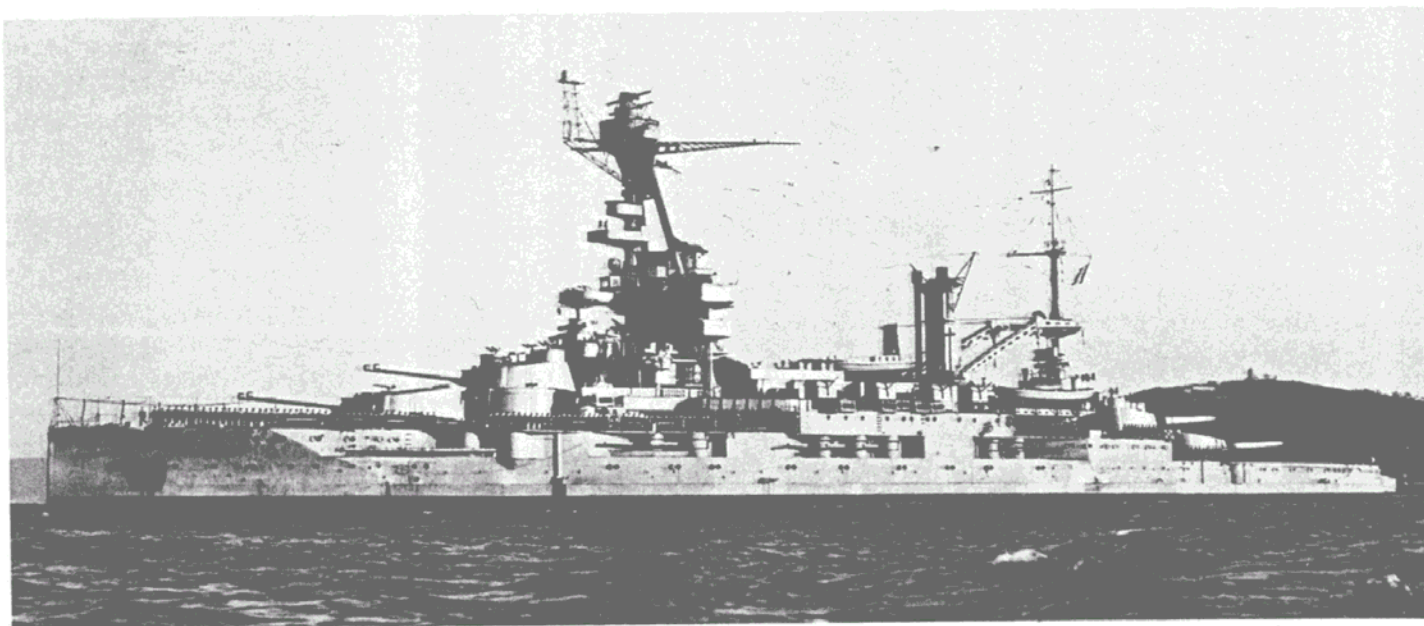
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Turrets. Of all the armor plate composing turret armor (not including the barbette), only the roof plate was dependent upon a simple ballistic calculation. The face plate had to be increased over its calculated required thickness an indeterminate amount to compensate for the weakening effect of the gun-port openings. Side-plate armor requirements simply could not be calculated, and the rear plate was generally determined by the requirements of turret balance.

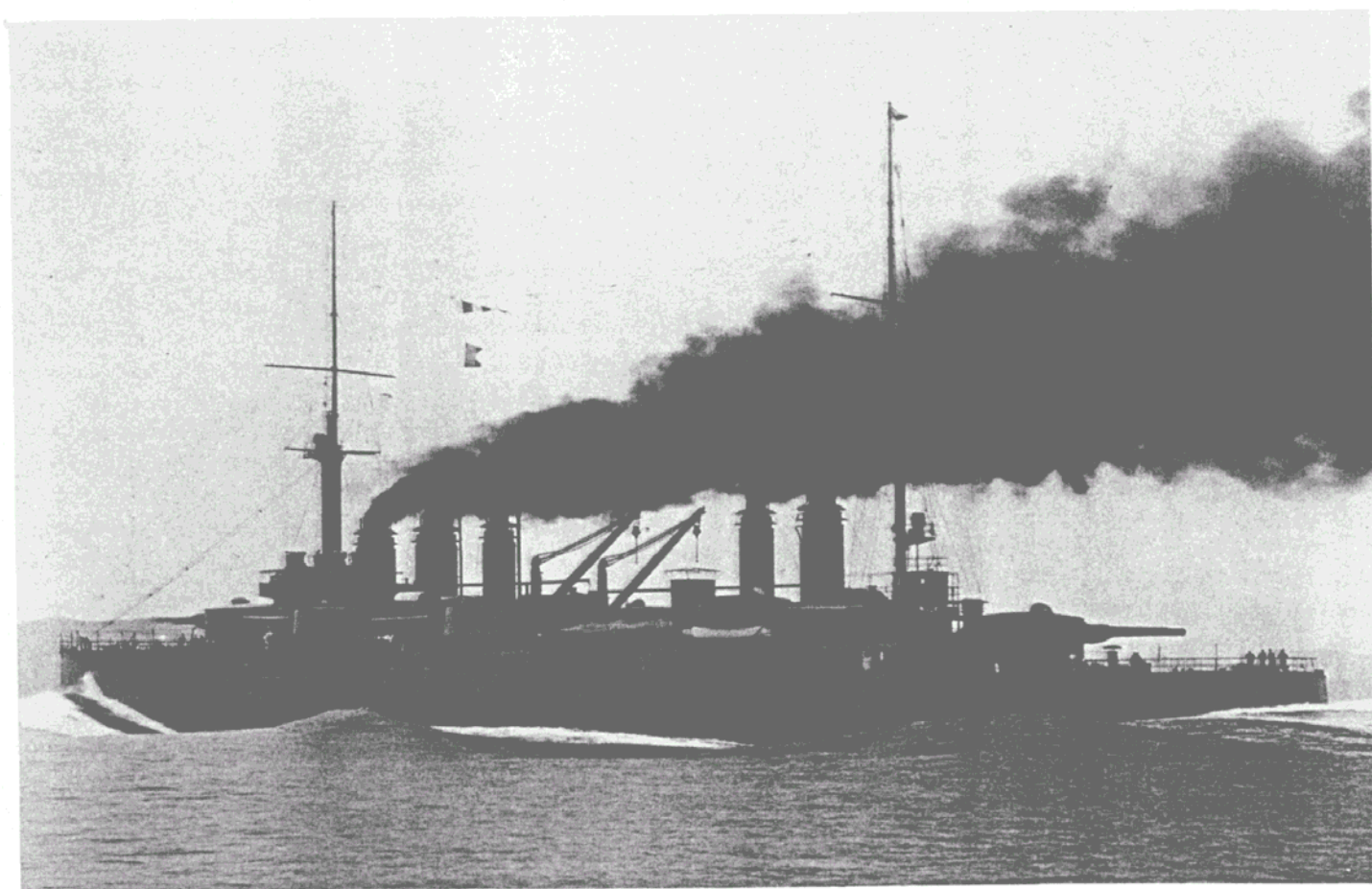
The roof armor of turrets was dependent upon a ballistic calculation; however, due to the unfavorable slope of the forward portion over the gun chamber (approximately five degrees) and the greater possibility of normal impact of a shell hit, the turret roof plate in this area usually was thicker than the flat plate on the turret aft. The slope of the forward portion was necessary for the depression of the main guns, which varied between three to five degrees, and so that headroom might be provided in the turret officers' booth and in the rangefinder. Each turret carried its own rangefinder in case of damage to those on the control towers.

The barbettes were constructed of face-hardened armor* and were dependent upon a ballistic calculation. The lower portion of the barbette, however, which was below the main armor deck, was not constructed of face-hardened armor and was reduced in thickness. Only splinter protection was necessary in this area.

* *Face-hardened armor*—Thick armor plates, used in way of belt armor systems, turrets, and the like. The face-hardening treatment (such as the famed "Krupp Cemented Armor") was designed to make the exterior surface of the armor particularly hard, while retaining the relatively tough, ductile properties of the backing armor steel. The surface hardening was intended to contribute to the breaking up of oncoming AP projectiles. Earlier armor steels, hardened throughout, proved to be relatively brittle (subject to cracking). The combined structure of the case-hardened armor steel retained the desirable exterior hardness, while adding the necessary ability to yield ductilely to heavy impact loadings without fracture. This type of armor steel is now rarely used in warship construction.



The unusual lattice structure on the foremast of the Lorraine mounted an American radar antenna, installed in 1943. The amidships twin 340-mm turret had been removed during a 1934-36 major conversion. (Marius Bar)

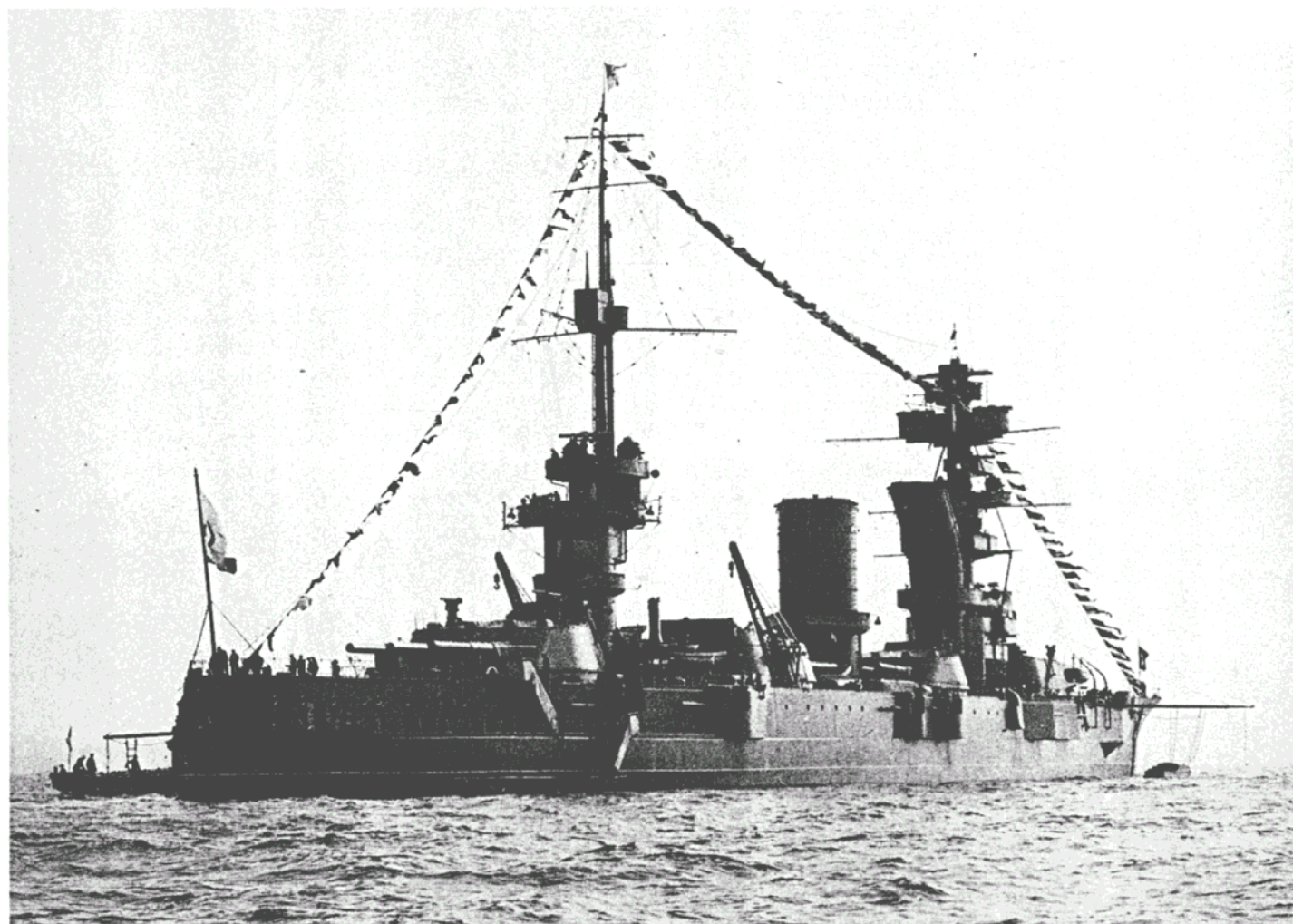


The Danton, completed in 1911, was a typical French pre-dreadnought, with a multiplicity of funnels, aggressive appearance, and ~~marked tumble-home~~.



21

The Hood, perhaps the most famous warship of the interwar period, was designed during World War I. Although many of the protective deficiencies of earlier Royal Navy battlecruiser designs had been corrected, the Hood remained a flawed—but beautiful—warship, as her dramatic destruction by the Bismarck in May 1941 was to show. (Marius Bar)



The Soviet dreadnought Marat (renamed Petropavlovsk in 1943) is shown here at the International Coronation Naval Review at Spithead in 1937. This was one of the first four dreadnoughts completed for the Imperial Russian Navy. The ships were built to an Italian design in Russian shipyards—such foreign assistance remained an important factor in Russian naval construction until after World War II.

As far as resistance to penetration is concerned, it is pertinent to note that a single deck of a given thickness provided considerably more resistance than two decks of the same total thickness. A single deck composed of two layers of plating was intermediate in its resistance. Hence, it was highly desirable to concentrate as much deck armor as possible on one deck.

In reviewing the armor systems of modern battleships, it appears that all battleships built after the Washington Treaty featured the "all-or-nothing" concept of armor protection in which armor was concentrated in the vital areas (main-battery turrets and machinery), while armor was stripped from nonessential portions of the ship. The concept was first introduced in the USS *Nevada* and was adopted as a procedure to reduce armor weight in the *Nelson* and *Rodney*. With the advent of the Washington Treaty of 1922, the limit on displacement was severe, and this in turn restricted the amount of armor that could be used in a modern battleship design. Therefore, from the aspect of protection, the Washington Treaty became a major factor in battleship design, necessitating the use of weight-saving schemes to enhance protection—such as the all-or-nothing concept of armor protection.

A tough yet flexible structure was vital to the effectiveness of the armor systems. The armor was designed to defeat projectiles by breaking them up, deflecting them, or resisting the effects of their detonation. Although a good understanding of explosive phenomena was important to the design of effective armor systems, it was vital in the design and construction of underwater protection systems.

Underwater protection systems. An imperfect knowledge of underwater explosive phenomena hindered the development of efficient side protection systems for World War II capital ships. Frequently, very crude empirical relationships derived from explosion tests were extrapolated to permit the design of new systems. Although even the most massive capital ship could never approach the ideal of the "unsinkable ship," it was possible to develop systems that would withstand several torpedo hits and enable a ship to remain in combat. Capital ships generally conformed rather well to this basic requirement, although larger World War II torpedo explosive charges exceeded the capabilities of earlier designs.

Appendix A of this volume lists several representative examples of the types of experimentation and ordnance trials that profoundly influenced capital ship design of the World War II era. The specific examples cited:

- A series of Royal Navy shell tests on the German battleship *Baden*
- A series of Royal Navy tests on the battleship *Monarch*
- The famous *Job 74* experiments that affected Royal Navy side protection design philosophy of the *King George V*, *Lion*, *Vanguard*, and *Ark Royal* classes.
- Ordnance trials on the USS *Washington* (BB 47).
- Trials on the *Empress of India* and *Marlborough*

Volume I contained data on the ordnance trials for the Japanese battleship *Tosa*.

Implicit in the design of side protection systems is the acknowledgment that it is impossible to fully protect the ship against the effects of a contact or powerful near-miss detonation. Tests did indicate, however, that side protection systems had to be at least 4 meters in breadth to provide protection to the vitals. This is due to the physics of the underwater explosion. On detonation, the solid explosive converts into a powerful gas bubble that expands in the direction of least resistance. If the detonation is sufficiently close to a ship, that direction is through the shell plating into the hull. A well-designed side protective system would permit the absorption of the destructive

effects or venting of the gases from the detonation without flooding beyond the holding bulkhead.

Any effective side protection system requires the following basic features:

- The exterior shell plating of the hull must detonate the explosive charge with the minimum possible fragmentation.
- The protective layer must allow the initial dissipation of energy by permitting the free expansion of gases resulting from the detonation. This led to venting plates in or outside the ship.
- The protective layer must absorb and contain the remaining explosive energy.
- The inboard boundary (the holding or torpedo protective bulkhead) must remain intact after the explosion of even a large charge.
- Individual bulkheads within the side protection system must have sufficient clearance to permit their maximum plastic and elastic deformation to the point of rupture without contacting the bulkhead inboard.
- The torpedo-defense bulkheads should be carried a deck higher than the side protection system in order to lessen stress concentrations as the bulkheads deflect under explosive loadings, thereby lessening the likelihood of flooding. This also contributes to a partial venting of the explosive gas bubble.

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Conventional side protection systems incorporated a series of longitudinal compartments with dewatering and counterflooding capabilities for effective damage control. Compartments were designed to be kept either liquid loaded or void; specific arrangements varied from design to design. The inboard boundaries of such systems were framed by a protective bulkhead, designed to remain watertight against underwater attack. Although later systems were more sophisticated, the design of World War II-era capital ships did make them resistant to underwater attack.

A typical side protection system such as that in the USS *Maryland*,* completed in 1921, incorporated five elastic bulkheads, with the inboard one designed to remain intact and watertight after an underwater explosion. The outboard void compartment permitted unresisted initial expansion of the gas bubble. Inboard were three compartments designed to be kept liquid loaded with fuel oil or water, to permit the inboard-bounding bulkheads to absorb much of the explosive energy as they were deformed and ultimately ruptured. The torpedo bulkhead was located inboard of a void compartment that was carefully kept at such a depth that the next outboard bulkhead would not strike the protective bulkhead before rupturing. A final dissipation of energy was achieved by liquid turbulence in this last compartment. The total breadth as well as the depth of the torpedo protection system were critical factors in its effectiveness, hence the advantage of large beams in protective-system design.

Unfortunately, the transverse depth required in an effective torpedo protection system prohibited its installation at the extremities of the ship. Generally, it extended the length of the armored citadel—about 55 percent of the waterline length. This left the bow and stern, and such vital equipment as rudders and propellers, exposed. Sir Eustace Tennyson d'Eyncourt, the designer of the *Nelson* and *Rodney*, found no practical means of protecting the rudders and propellers and called them the Achilles heel of the battleship. This weakness was dramatically demonstrated during the *Bismarck*'s last engagement (24-27 May 1941), the loss of the *Prince of Wales* (10 De-

* Manning and Schumacher, *Principles of Naval Architecture and Warship Construction*, (Annapolis: U.S. Naval Institute, 1928), Plate IV, "Midship section of USS *West Virginia*."

cember 1941), and the near loss of the *Vittorio Veneto* during the Battle of Cape Matapan with British forces.

One of the most difficult problems in designing a torpedo defense system for the modern capital ship, aside from the constantly accelerating size of explosive charges, was the provision of adequate torpedo protection near the ends of the armor box, particularly with very fine hulls of prismatic coefficients less than 0.61. Because of the emphasis on speed, large boiler and engine rooms were necessary, although these were less in volume than those of battleships designed from 1915-25. With magazines forward and aft of these spaces, it was necessary to provide reasonably full hull sections at the quarter points, particularly at half draft. With somewhat reduced beam and magazines in the vicinity, torpedo protection near the ends of the armor box was of the greatest importance. Furthermore, the floodable length* is least in the vicinity of the quarter points, which is yet another important reason for obtaining the best possible torpedo protection in these areas.

In addition to the problem of these "quarter points," there was the passage of shafts through the torpedo bulkheads aft. This was a difficult problem in the high-speed battleship for either a three-shaft or four-shaft arrangement. The center shaft in the three-shaft and the inner shafts in the four-shaft arrangements passed through the hull well aft and clear of the region which required torpedo protection, but the outboard shafts had to pass through the torpedo bulkheads with a long diagonal intersection. It appears that the three-shaft arrangement was more of a problem because its outboard shafts had to pass through the main torpedo bulkhead, near the quarter point whereas the outboard shafts in a four-shaft arrangement did not. The integrity of the torpedo bulkhead system at these points was approximately maintained by incorporating the shaft alley bulkhead as a partial torpedo bulkhead. Based upon war damage in these areas, it appears that the torpedo protection of all capital ships was somewhat defective in the stern.

Subdivision. Although highly important in restricting flooding, subdivision is at best an imperfect means of protecting a ship. Normally, fragmentation damage resulting from a bomb, shell, or torpedo hit is sufficient to riddle numerous watertight bulkheads in the vicinity of the hit. As a consequence, considerable flooding often resulted even when the damaged ship had excellent subdivision. Despite this shortcoming, the subdivision of all warships was a most important factor in their resistance to damage.

In high-speed capital ships, the protection of bow and stern areas became very important. As sufficient armor protection was impossible, the most extensive practical subdivision was essential to minimize flooding after damage. The death throes of the Japanese battleship *Musashi* is mute testimony to this. The *Yamato* class had very large compartments forward and aft of the armor box, and when damaged, large trims ensued. Not only did this reduce speed, but it made the vessels very difficult to handle. This vulnerability was met in most navies by attempting to keep the armored citadel large enough to permit the ship to remain upright and stable with both extremities flooded, provided the citadel within the torpedo-protective bulkheads remained intact. In the *Richelieu* class, a large compartment just forward of the armored box was filled with a water-exclusion material to prevent excessive bow trims in the damaged state.

* *Floodable length*—The maximum distance between two main, transverse watertight bulkheads ensuring no more than the permissible sinking of the ship, that is, to the margin line. This line is independent of the bulkhead deck, which is the deck to which these transverse watertight bulkheads extend.

During the period of design of the modern capital ship, subdivision was also considered necessary to control the spread of noxious gases. It proved of little importance in World War II, as such gas attacks never materialized.

Radar. When most capital ships of the World War II era were designed, the requirements of electronics equipment played a very small role. Optical range finders were more important factors in the operation of the guns, and their placement aboard ship was carefully thought out. By the end of the war, however, the efficiency of electronic gear, particularly radar, was a major factor in evaluating a ship's performance.

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Optics. An important feature of battleship design in the preradar era was the necessity of control towers—usually one forward and another aft—where the main and secondary battery optical rangefinders were mounted. It was also important that these towers be high enough to permit uninterrupted lines of sight at least 23-30 meters above the design waterline. Two main-battery and four secondary armament directors were deemed essential in modern battleship design. One of the most serious problems was the placement of the after control tower due to the interference of stack gases. An ideal solution would have been to place the stack abaft the after control tower, but this was difficult to accomplish in a ship with the main guns arrayed forward and aft and the propulsion plant amidships. It was not possible to arrange the boilers aft and the engines forward, since the boiler heights and the necessary shaft clearances made this difficult if not impracticable.

In many battleship designs, the stack was carried about four meters above the after main-battery director, and the after control tower was moved as far aft as possible. In the British *Lion*-class battleships (1938 design), the after control tower was mounted on "Y" turret. These solutions hoped to minimize but not avoid the gas interference problem. The decision to keep the after control tower small to reduce the eddying problem of stack gases inevitably meant that the directors for the secondary armament had to be mounted on structures adjacent to the stack or outboard to provide good lines of sight.

Protection of these spaces was limited to splinter type—usually 10-20-mm thicknesses. Greater protection was not possible due to the large weights that would have been involved and the adverse effect on the vertical center of gravity and ultimately the metacentric height (GM).

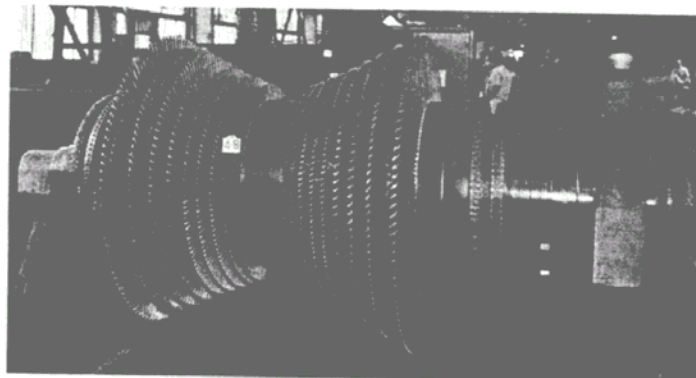
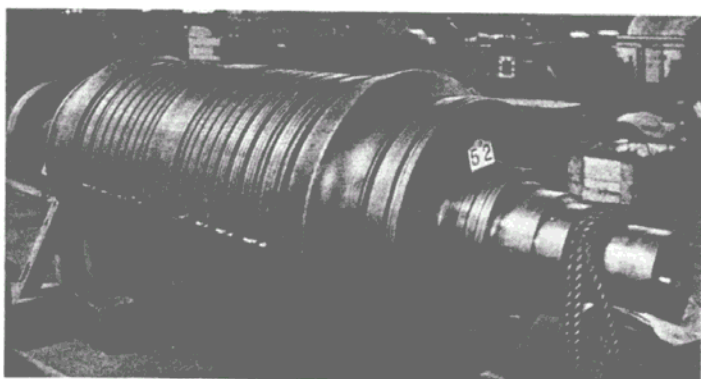
Electronics. Search-radar equipment developed rapidly to the point where long-range contacts were commonplace. The classic surface engagement of the Battle of Surigao Strait (25 October 1944) resulted in the near annihilation of a Japanese force in a night action during which American ships tracked them by radar and used radar fire-control equipment.

Air-search radar proved to be of enormous value in the antiaircraft defense of surface ships. By often detecting enemy aircraft at ranges in excess of fifty miles, it permitted vectoring fighters to meet the attack and alerted antiaircraft batteries in ample time to put up effective fire.

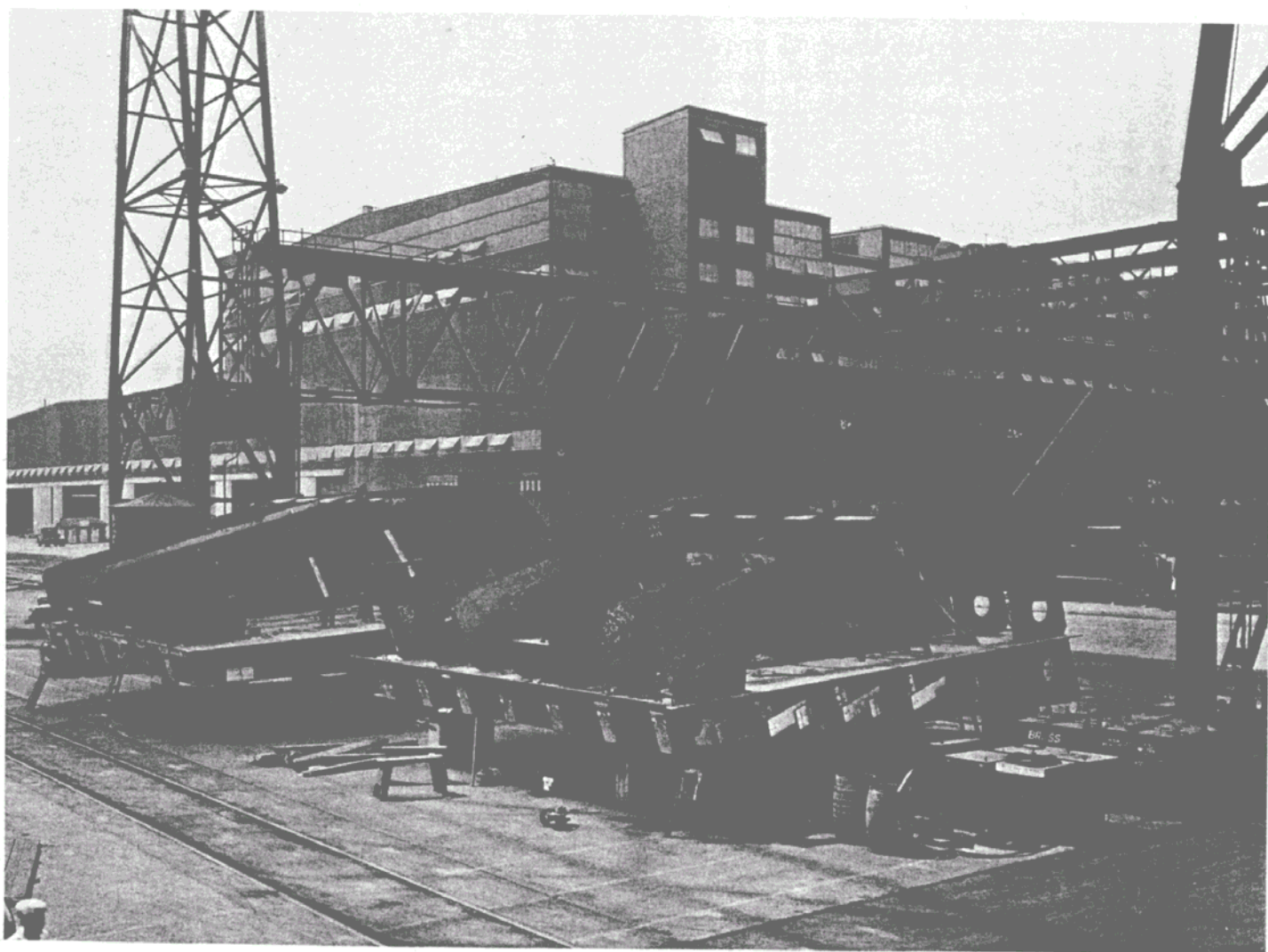
As used by the Royal Navy, the combination of radar-directed antiaircraft guns and the VT fuze was highly effective in antiaircraft defense, although by no means a complete defense against determined attack.

The increasing complexity of naval warfare forced a major growth in the communications facilities of all ships, leading to the installation of literally dozens of transmitters and receivers. The net effect was the proliferation of electronics spaces in

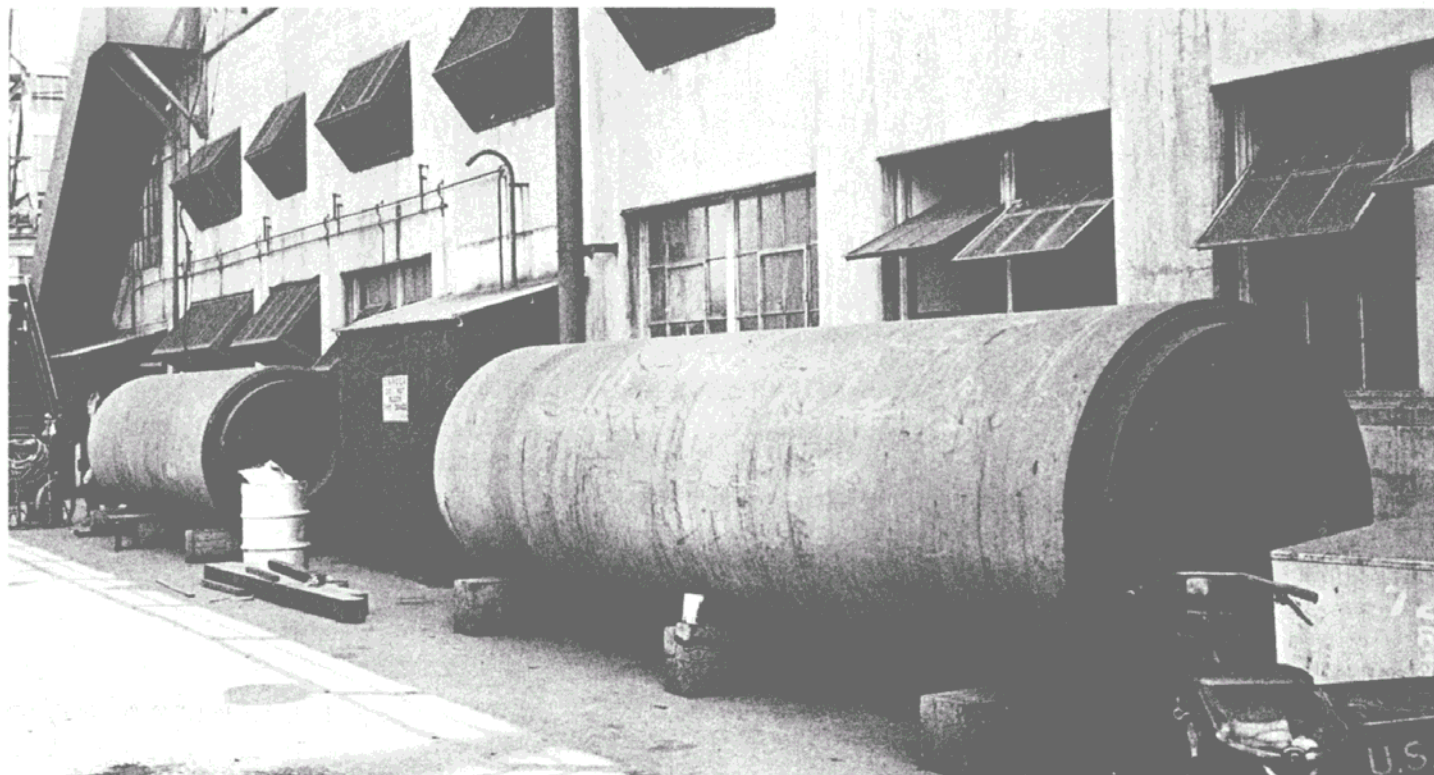
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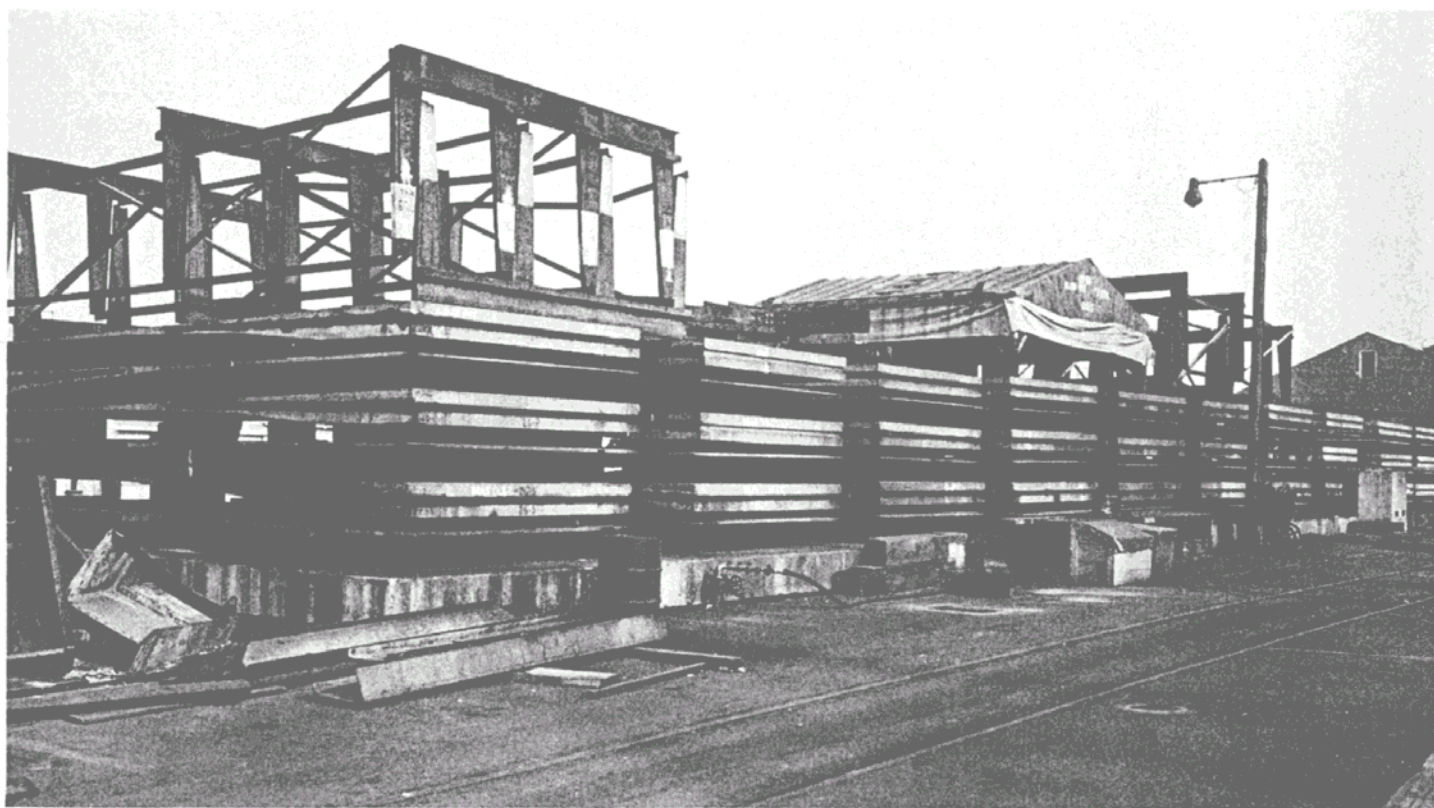
Battleships represented an enormous investment of industrial and technical resources. One example of this investment is shown here. Modern steam turbines required the assembly of complex precision-machined components. The left view shows a low-pressure turbine rotor before assembly of the blading. A nearly completed turbine rotor is shown at the right.



Prefabricated tank assemblies of the torpedo protection system for the incomplete American battleship Illinois. The massive size of these passive systems is hinted at here. In many ships these systems extended almost half the length of the ships, with a lateral extent of 16 to 20 feet.



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The sheer massiveness of heavy battleship armor is vividly shown in these two 1945 views of armor intended for the never-completed American battleship Illinois. The massive communications tube, with 16-inch sides, shielded access between the conning tower and the armor deck. The lower view shows tapered side armor plates, from 12.2 inches to 1-inch thick.

the superstructures, to the detriment of habitability and battle-worthiness. Ironically, the electronics installations essential to the combat effectiveness of a ship are perhaps the most susceptible to damage of all vital systems on board. Consequently, a ship with electronics gear of necessity located in the superstructure was much more susceptible to crippling damage than a comparable ship of an earlier era.

Propulsion Plant. The generally accepted need for high speed markedly influenced modern designs, and all capital ships of the World War II era were designed for speeds of at least 27 knots. Such ships were distinguished by their great length and very fine lines, designed to attain higher speed by minimizing underwater hull resistance. The relatively fine hull form caused the machinery plant and main armament to be located farther aft than in World War I battleships. Wave-making resistance, created by the generation of waves as a ship moves through the water, depends on the hull form, speed-length ratio,* and similar features. Such resistance—as much as 40 percent of the total at high speeds—can be minimized by fine bow forms, well-designed stern shapes, and efficient longitudinal distribution of buoyancy. Frictional resistance, on the other hand, is a result of the relative motion of ship and water and waves in proportion to the wetted surface areas of the hull. Hence, there is some contradiction in the desire to reduce the speed-length ratio (i.e., increase length) to lessen wave-making resistance, because the effect of the increased length (greater surface area) results in more frictional resistance. Overall, the advantages of increased length offset the disadvantages of increased frictional resistance, hence the consistent adoption of long hull forms for high speed.

As speed requirements were increased, the demand for more powerful propulsion plants was enormously increased. This trend was particularly serious because of the effect of increased speed on the resistance of displacement hulls—power requirement varies at least with the cube of the speed. For example, if 32,000 shaft horsepower drives a ship at 20 knots, some 62,500 shaft horsepower might be required for 25 knots, and 108,000 shaft horsepower for 30 knots—a 50 percent increase in speed requires more than a 235 percent increase in power!

Model-basin tests. As a consequence, extensive model-basin tests were made, seeking the best possible hull form to permit the highest speed with the least possible power. The tests generally indicated that a block coefficient† from 0.55 to 0.60 should be combined with a speed-length ratio of at least 1.0 in order to minimize power requirements for high-speed operations. At speed-length ratios greater than 1.0, the majority of the total resistance can be attributed to wave, form, and eddy resistance. The greater lengths and finer hull forms resulted in substantial fuel and power savings. Large bulbous bow structures became common, reducing wave-making resistance and the power required for high-speed operations. Although the details of the

* Ratio of the ship's speed in knots to the square root of the waterline length in feet—an index of the effective speed of the ship in terms of resistance. The lower this ratio, the less the resistance per unit area of hull wetted surface. This is one of the prime reasons that high speed ships are usually relatively long.

† The ratio of the actual hull displacement volume to the product of the waterline length maximum waterline beam, and maximum draft. It is another index of the suitability of the hull form to high-speed operations. The lower this ratio (a rectangular form has a value of 1.0), the more fine the hull form, but the less available volume for any given set of dimensions.

various hull forms varied, in all cases the hull geometry was the result of careful consideration of all factors involved.

Model-basin tests in the United States, Great Britain, and Japan evaluated various forms of twin keels or skegs from the standpoint of propulsion efficiency, hull resistance, and shielding the inner shafts. Interestingly, while American tests on twin-skeg models demonstrated such outstanding improvements in propulsive efficiency that all new U.S. battleships were given such a stern form, Japanese and British tests indicated an *increase* in the required power. Notwithstanding such contradictions, and despite the complexity of the design problems, model tests were of considerable value to the development of hull forms.

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Design effect on power. Although improved hull forms somewhat alleviated the problems confronting the marine engineers, the remaining requirement—compact and powerful main-propulsion plants—was a major design challenge. In general, these problems were met by lighter weight propulsive equipment, higher steam temperatures and increased pressures, improved boiler design, improved mechanical reliability, and electric arc-welding.

The United States and German navies were especially bold in the adoption of steam turbine plants with relatively high pressures and temperatures. All other factors being equal, a steam turbine installation designed for extreme operating conditions can be more compact and efficient than a traditional, conservative design. As might be expected, there are complicated metallurgical problems involved in the adoption of more severe steam conditions, and German ships in particular were plagued by operational casualties caused by equipment failures, particularly in the boiler tubes. Many navies settled for more traditional designs, sacrificing speed for improved operational reliability and durability.

Diesel power. Although several German capital-ship designs featured main propulsion diesel engines, no capital ships with diesel propulsion were completed during the World War II era. Diesel engines are most economical in terms of fuel consumption but are relatively heavy for their power. As a result, ships with diesel installations are normally somewhat slower than those with turbine-drive, although capable of considerably better endurance.

Electrical installations. The increased electrical requirements of modern capital ships demanded powerful generator installations. Normally, electrical plants were separated into several compartments in an effort to improve combat effectiveness after damage. Although there was no consistent trend toward either steam turbine or diesel drive, and there were variations between different classes of ships in the same navy, all navies—with the exceptions of the U.S., French, and German Navies—used direct current for almost all shipboard purposes. The U.S. Navy had pioneered with alternating current, and all American ships featured AC installations. There are numerous advantages in using AC as compared to DC power—weight, efficiency, compactness, and reliability. The larger capital ships had a maximum generating capacity of about 10,000 kilowatts.

Ship Construction. In an era of treaty displacement limitations and emphasis on high speed, the efficient use of structural weights was of paramount importance. Careful analysis of structural design arrangements and construction techniques became of particular consequence and resulted in considerable progress.

The conventional riveted construction of steel ships, requiring the overlapping of plates and additional material to ensure structural strength in areas of heavy loading, caused excess weight, and riveted joints were known to be weak points in the overall structure. Welded joints compared in strength to the base metal.

Welding. Unfortunately, welding technology was insufficiently developed when modern capital ships were designed and built, and there were not enough skilled welders. There was, however, a consistent trend towards greater use of welded joints in nonvital structural members.

As a consequence of the enormous advantages of structural welding, considerable experimental and developmental work was devoted to improvements in welding techniques and material. Interestingly, wartime experience with volume production of relatively simple welded structures revealed the seeming contradiction that the superior-strength welding technique was less demanding of shipyard workers' skills than riveting. The mass production of auxiliary and escort vessels was considerably facilitated by the extensive use of welding. Capital ships, on the other hand, relied on riveted structure for vital armor systems and major structural members, as the integrity of welded members under explosive loadings was suspect. In the long run, the trend in ship construction was decidedly in favor of welding, and riveting has disappeared from the scene as a factor of consequence in ship construction.

Framing systems. Two basic structural systems were used in capital-ship construction. The transverse framing system consisted of closely spaced continuous frames with widely spaced deep longitudinal members connecting adjacent frames. Such a system is relatively rigid and heavy. The longitudinal framing system is characterized by widely spaced transverse frames joined by numerous closely spaced shallow longitudinal members. This system is more flexible and considerably lighter for a given designed stress level. Normally, transverse framing arrangements were necessary amidships to help support the massive turret structures as well as the deck and side-armor systems, while longitudinal systems at the extremities helped to conserve vital structural weight.

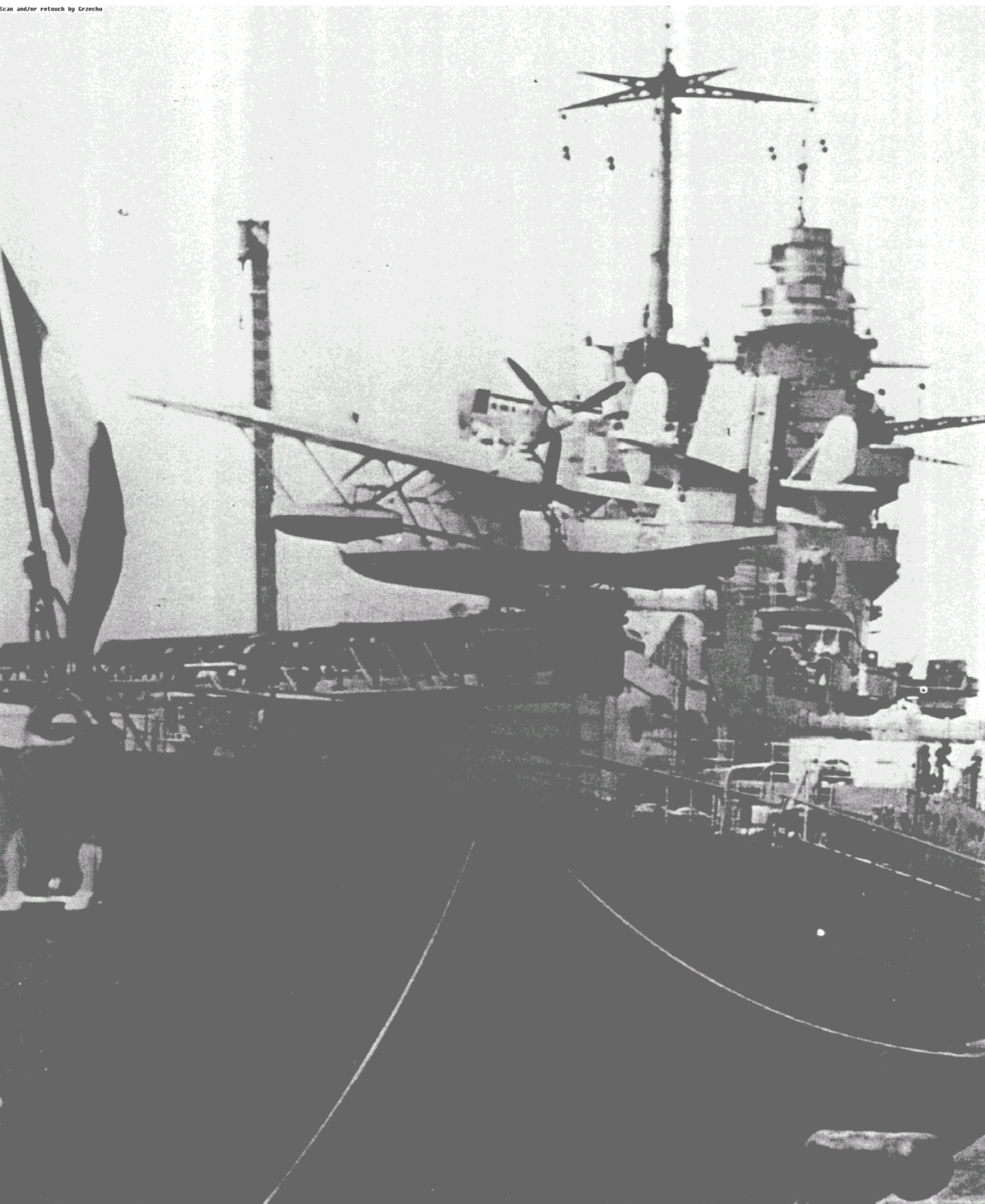
Political effects. Domestic and international political considerations often played major roles in capital-ship design and construction. The enormous expense and industrial effort to build even one capital ship often made the construction of such ships a matter of considerable domestic controversy. Construction was often delayed owing to political considerations, and at times such concerns led to the cancellation of major projects. In France, for example, the approval of funds for the *Strasbourg* came during an all-night session of the Parlement, and the next morning the French nation arose to hear that after considerable debate a second *Dunkerque*-class ship would be built.

The most obvious international political factors were the treaties establishing displacement and armament limitations. Of somewhat lesser consequence was any one government's concern as to the reaction of another to the construction of new capital ships—for example, the German decision to retain 283-mm guns in the *Scharnhorst* and *Gneisenau* in an effort to allay concern in the British government. Meanwhile, the Royal Navy arbitrarily limited the displacement of the *Lion*-class ships to 40,000 tons standard (despite the treaty limit of 45,000 tons) in the (vain) hope that other European naval powers would follow the example of design moderation, thereby enhancing the relative combat value of the smaller *King George V* class and perhaps

limiting the escalating size of these ships. That this was a mistake is clearly shown in France's intention to build a 45,000-ton improved *Richelieu* (the *Alsace* class), the Russian initiation of construction of a 62,000-ton behemoth, Germany's *Bismarck* and Battleship "H" of even larger displacement, and the Italian *Vittorio Veneto* of 40,000+ tons.

All navies, of course, can be strongly influenced by a powerful chief of state or dominant individual. A classical example of such influence in Great Britain was Winston Churchill, who, while a member of Parliament, kept in constant contact with the Admiralty during the design of the *King George V* and *Lion* classes. When he became First Lord of the Admiralty in September 1939, a signal went out to the fleet, "Winston is back!". On 8 October 1939 he informed the First Sea Lord that "a supreme effort must be made to finish the *King George V* and *Prince of Wales* by their contract dates. The peacetime habit of contractors in booking orders and executing them when they please cannot be allowed to continue in time of war. . . ." He followed this up on 21 October 1939 with another plea to the First Sea Lord to have these two battleships completed as quickly as possible. In December 1939 Winston Churchill expressed an interest in the *Vanguard* design, since it represented a battleship that could be built during the expected duration of the war and did not require new main-battery turrets. On 19 February 1940, Sir Stanley Goodall, the Director of Naval Construction, was instructed to proceed with the design. In the subsequent months the design was reviewed and altered, but construction finally began on 2 October 1941. After the Battle of Midway in June 1942, some consideration was given to converting the *Vanguard's* hull to a carrier. When this matter was brought up at a meeting, Winston Churchill was present and he vetoed the proposal, insisting that the *Vanguard* must be completed as a battleship. In fact her construction had been given top priority at John Brown Shipyard—causing the cancellation of a cruiser and some merchant-ship construction. Therefore, Churchill's preoccupation with battleships was an important reason why the *Vanguard*, Britain's last battleship, was completed in 1946.

In France, the appointment of Admiral Darlan to command the French fleet was the most important development in the French Navy in the years before World War II. Under his dynamic leadership, the French Navy became the world's fourth most important naval power, with the addition of new cruisers, destroyers, and battleships. In the Soviet Union, Joseph Stalin was interested in battleships, but the industrial base of the Soviet Union could not support the development of a massive navy and army. Therefore, after Germany invaded Poland, more emphasis began to be placed on the needs of the army, and armor-producing plants began turning out plates for new tanks of the T-34 type.



CHAPTER TWO

The Dunkerque class

France went into World War I with a navy totaling 690,000 metric tons, and another 257,000 metric tons of combatant craft, including battleships, under construction. Four more battleships of 29,600 metric tons displacement each were on order. During the war, the French Navy lost 40 percent of its fighting strength. These ships could not be replaced because the French Army had been given military and industrial priority. By 1918, only four of the five *Normandie*-class battleships had been launched, but outfitting had been halted; the fifth ship had been canceled. The 340-mm and 140-mm guns intended for these ships were requisitioned by the French Army and sent to the front, while their boilers were used for patrol vessels or destroyers.

By 1920, work on the *Normandie* class had been definitely canceled, because the Conseil Supérieur (equivalent to the General Board or Ships Characteristics Board of the U.S. Navy) believed it unwise to progress with further battleship construction when the United States, the United Kingdom, and Japan were building or projecting battleships of far greater offensive power. The French Navy still regarded battleships as essential, but the state of the French economy would not permit the construction of a new battleship class or the extensive remodeling of the five *Normandie*-class ships. Opinion was also divided within the French Navy as to which type of warship should be constructed in the future. Interestingly, the 1920 naval budget included an appropriation for experiments with a 457-mm/45-caliber gun, including ammunition and proof armor. Ultimately, of the five incomplete *Normandie* hulls, one was converted to the aircraft carrier *Bearn*, and the others were scrapped.

With much of her fleet obsolete and with considerable colonial interests, France attended the 1922 Disarmament Conference. France was compelled to accept naval parity with Italy, and they both were allocated 175,000 tons for capital ships. Moreover, government policy and public opinion during this period were also adverse to the needs of the navy.

In 1924, the French Navy sought a new building program to replace the 1912 program which had been abandoned due to the exigencies of war. The basic intent was to secure from the Parlement in Paris its long-term approval of naval construction funds (*Statut Naval*), so that over the concerned period the necessary yearly appropriations would be automatically included in the annual defense budget. The proposed end-date of this program was set at 1 January 1943, by which time the French Navy would be at the maximum strength prescribed under the Washington Treaty. The French Parlement, however, refused to go along with this, since it wanted to review annually the French Navy's proposals for new construction. Although the *Statut Naval* was not approved, it remained the principal guideline in the reconstruction of the French Navy until the eve of the Second World War. Therefore, the navy requested

This stern view of the Strasbourg clearly shows the aviation facility at the stern. A Loire-Nieuport 130 floatplane is poised for take off on the single catapult. Three aircraft could be carried—two folded in the hangar and a third stowed on the catapult. (Musées de la Marine)

an average yearly quota of 40,000 metric tons of new construction to meet its anticipated needs. Due to disarmament negotiations and parliamentary reviews of the annual naval budgets, the average yearly construction totaled some 33,000 metric tons. During 1924-30, major concern was centered on destroyer and cruiser-type ships, although some design work continued on capital ships. Under the provisions of the 1922 Washington Treaty, France could commence the construction of a capital ship in 1927, since she had been unable to complete any new battleship construction during the First World War.

In 1926, when three of the most recently constructed French battleships, the *Bretagne*, *Lorraine*, and *Provence*, were ten years old, the Conseil Supérieur requested the Service Technique Constructions (similar to the Naval Ship Engineering Center in the U.S. Navy) to study "croiseurs de combat" (a type of battlecruiser) which would conform to the limitations of the Washington Treaty. The conclusions of the study were in favor of a battlecruiser capable of:

- Destroying treaty cruisers which were being built by most naval powers;
- Attacking merchant ships in convoys protected by battleships with speeds of 20 to 25 knots;
- Composing a powerful scouting force among a combined Allied fleet in which the French Navy would be a partner.

Studies began in 1926 on several prototypes. The first design study resulted in the characteristics tabulated in Table 2-1.

TABLE 2-1

Characteristics of a 17,500-ton Croiseur de Combat

Standard displacement	17,500 tons (17,800 mt)
Waterline length	639.76' (195 m)*
Beam	80.38' (24.5 m)
Armament	
Main	Eight 12"/55 (305-mm) guns in two quadruple turrets. These guns were to have a muzzle velocity of 3,200 fps (965 mps) and a range of 48,000 yards (44,000 m).
Secondary	5.1" (130 mm)
Speed	34-36 knots
Protection	Armor thicknesses to be based on an 8" (203-mm) shell with a muzzle velocity of 2,800 fps (850 mps).

* Authors' estimate

Much of the detail of the above design has been lost, but some estimates can be made of protection and ship dimensions from other French warships built or designed during this period. Although these were to be fast ships, their limited displacement forced some compromises. The armored citadel had to be predicated upon the 203-mm shell, and the limited beam of 24.5 meters did not permit a deep underwater protection system necessary during a period when torpedo attack was an important criterion in capital-ship design. The thicknesses of armor envisioned probably would have been similar to that used in the *Algérie*, a heavy cruiser built during the early 1930s. The main side belt in this particular French warship was 110 mm with an upper armored deck of 80 mm. To limit the extent of the armored citadel, the main armament was to have been concentrated into quadruple turrets, with the secondary armament featuring a rapid-fire, dual-purpose gun of 130 mm. Eight aircraft were also contemplated; there were to be catapults fore and aft. The propulsion plant was to feature an unusual

combination of geared turbines with diesel engines for cruising. The lack of adequate protection, however, and the concentration of the propulsion plant and armament would have made these ships very vulnerable.

When Germany announced the construction of the nominally rated 10,000-ton *Deutschland* in 1928, France ceased design work on its 17,500-ton battlecruiser. A new series of design studies commenced, with emphasis shifted to protection and gun power. Speed was reduced; armor plate of 203-305 mm was necessary to resist 280-mm shellfire at battle ranges. French designers considered it important to destroy this German ship with as few hits as possible, and it was advocated to increase the gun size from 305 mm to 330 mm. Two ships of the same design were proposed. However, their construction, in addition to destroyers, cruisers, and auxiliaries, would have resulted in the French Navy's exceeding its average yearly quota of 40,000 tons. Although France was allotted tonnage to construct new capital ships by the Washington Treaty, her Parlement was unwilling to increase naval construction to accommodate these ships, which would have been much larger than their German counterparts. In the meantime, discussions about French battleship construction were conducted with British representatives in 1927 at Geneva. The British representatives were anxious that France and Italy construct 25,000-ton ships with 305-mm guns. The French Navy was unwilling to agree to such a limit. Nevertheless, the British government persisted in its efforts to limit battleship size. In 1930, a second conference on naval construction was called in London. The French were anxious to have the restrictions of the Washington Treaty relaxed concerning the size of her battle fleet, but the British were reluctant to release France from these obligations, since they wanted to maintain naval parity between the French and Italian Navies. The French and Italian representatives would not accept a 305-mm limit for the main armament or a 25,000-ton displacement for their new capital ships. After much debate in somewhat stormy public and private sessions, the French and Italians withdrew from the conference.

After the London Naval Treaty had been signed, the British government held separate negotiations with the French and Italians in an attempt to reach an accord on future battleship construction and have them, belatedly, sign the London Accord. French and Italian naval authorities also met at a number of meetings after March 1930 and unofficially reached a mutual understanding that would preserve the naval parities within the confines of the Washington Treaty limitations. The French government reluctantly approved its navy's recommendations on these naval parities, but even though many discussions were held between the French and Italians, and regardless of the pressure brought to bear by the British, no signed agreements were ever promulgated. Nevertheless, there was an unofficial mutual understanding reached that no more than two 35,000-ton battleships would be constructed between 1931-37 and that smaller capital ships could be constructed that would not exceed 70,000 tons (i.e., four ships of 17,500 tons or three ships of 23,333 tons).

In the meantime, French naval constructors, responding to a request from the Conseil Supérieur, had been studying a series of battleship designs of ships that would mount 305-mm and 330-mm guns and have displacements ranging from 23,000 to 35,000 tons. A few designs with 380-mm and 406-mm guns were also considered, but the main effort was concentrated on a design featuring a 25,000-ton displacement and the 305-mm gun. By 1930 a new design had been prepared to upgrade the armor protection against the German 280-mm gun and the ever-increasing menace of the torpedo, since it was now possible to take advantage of a larger displacement. The characteristics of the design are summarized in Table 2-2. To increase the protection, the speed was decreased, but the caliber of the main battery was retained at 305 mm. The French Naval Staff was not happy with this main battery and advocated its

TABLE 2-2

Characteristics of 1930 Croiseur de Combat

Standard displacement	25,000 tons (25,400 mt)
Waterline length	672.57' (205 m)*
Beam	90.22' (27.5 m)
Armament	
Main	Eight 12"/55 (305-mm) guns in two quadruple turrets.
Secondary	5.1" (130-mm) guns
Speed	29-30 knots
Armor	
Side belt	8.46"—9.06" (215 mm to 230 mm)
Decks	3.94"—5.12" (100 mm to 130 mm)

* Authors' estimate.

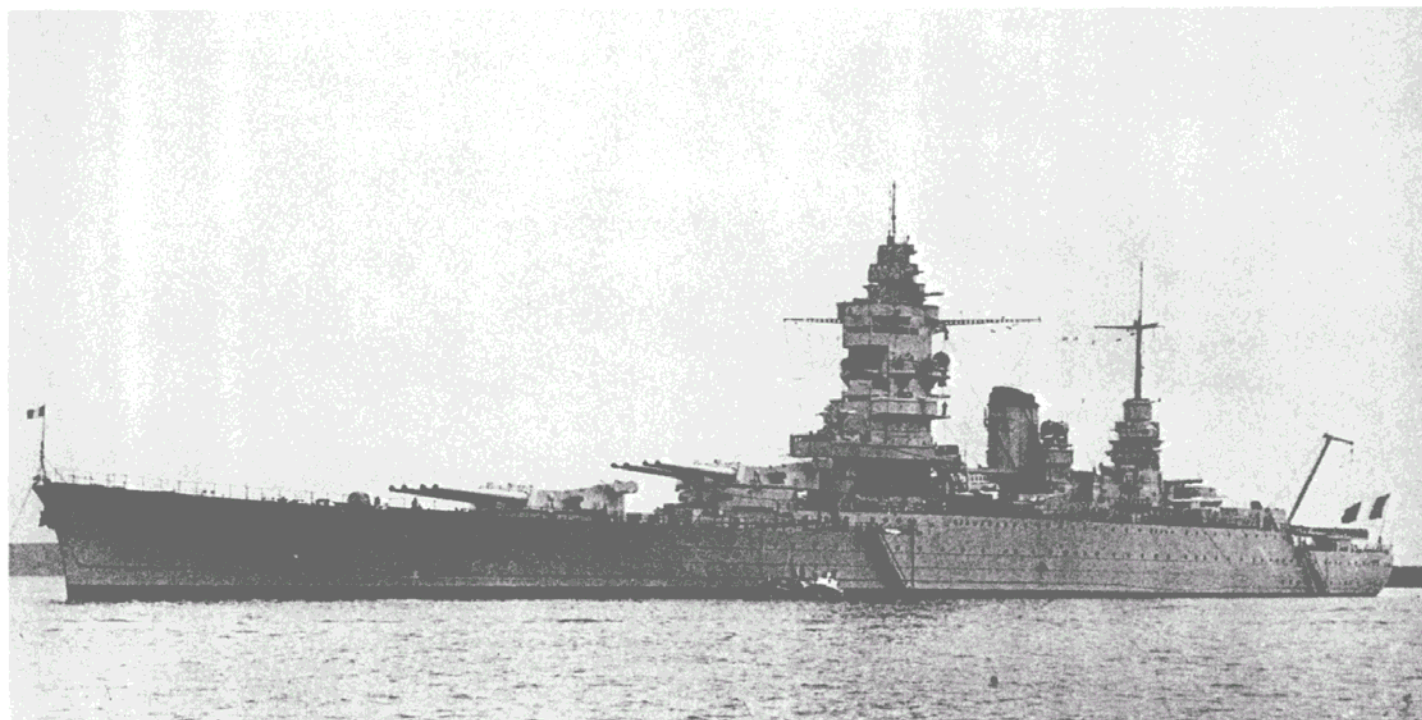
increase to 330 mm. Only a larger displacement, however, would permit the larger caliber.

The 130-mm guns used in the French destroyers of the *Jaguar* and *Bourrasque* classes were powerful guns for their size, but had a relatively slow rate of fire of six rounds per minute. This was not sufficient for antiaircraft defense, and it was felt at the time that capital ships should be provided with good antiaircraft fire. A dual battery on a displacement-limited warship was not considered practical. Consideration of the type of action in which these ships would be involved required a rate of fire of at least eight rounds per minute and faster elevation and training rates for a turret or mount. Since there were a number of ex-German light cruisers and destroyers in service with the French Navy after World War I, it was also decided, after commentaries from the fleet, that the sliding breechblock mechanism should replace the hand-worked rotating breech mechanism. After much discussion it was finally agreed that the new French capital ships should be armed with dual-purpose 130-mm sliding breechblock guns in sufficient number to provide good antiaircraft and antiship protection. These guns were to be supplemented by 37-mm and 13.2-mm machine guns.

Deliberations by the Conseil Supérieur in March 1930 determined some of the features of the new "battleships." Deck armor was specified that would resist the penetration of a 500-kilogram bomb dropped from an altitude of 3,000 meters. The main armament was to be increased from 305 mm to 330 mm and to be grouped forward as in the British *Nelson* and *Rodney* in order to reduce the armor citadel. The concentration of the main battery into two turrets was also a weight-saving expedient. The Conseil Supérieur asked the Service Technique Constructions to develop the characteristics of this "croiseur de combat." The requirements are listed in Table 2-3.

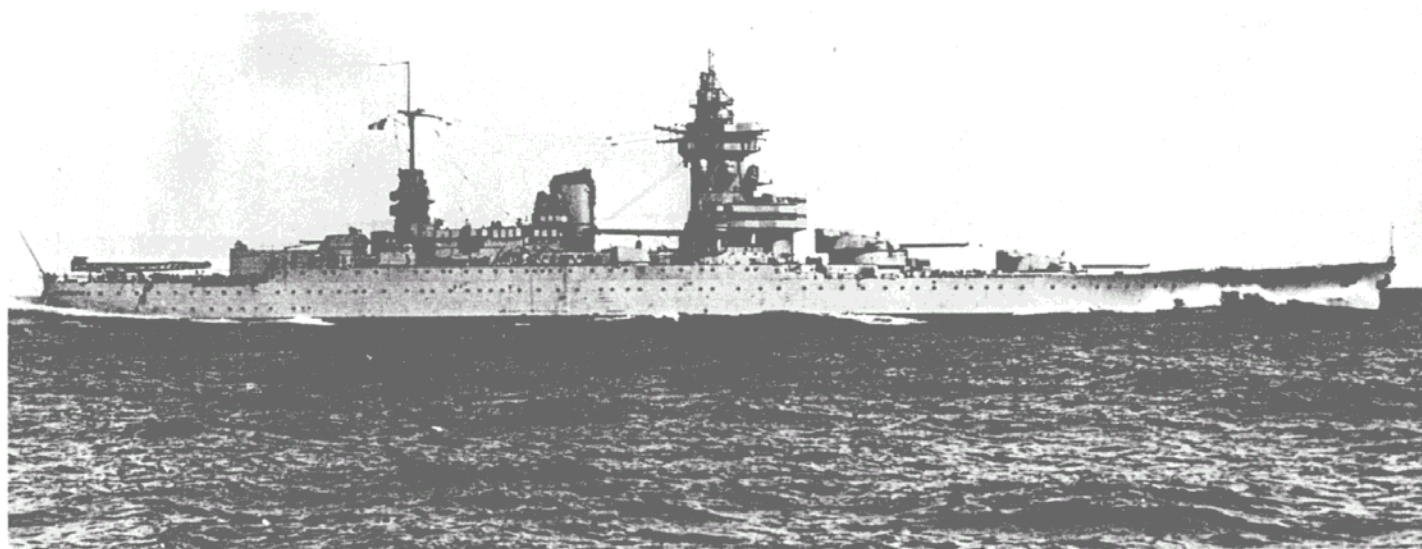
These requirements formed the basis of the *Dunkerque*-class design which was completed in 1931. The most difficult problem in resolving the final dimensions was the standard displacement. The increase in the gun size to 330 mm, the protection sought, and the speed desired made it impossible to produce a ship of 25,000 tons. It was decided, after much discussion, that the standard displacement should be raised to 26,500 tons to accommodate the objectives sought by the Conseil Supérieur.

Enthusiastic French supporters of the submarine and airplane criticized the construction of these ships; accordingly, the new dreadnought would have novel features not found in older battleships and battlecruisers. She would have to resist conventional torpedo and mine attack, as well as gunfire from a *Deutschland*-class armored ship. Looking ahead to developments in warfare, it was believed that the airplane would become a more potent weapon and thus this French warship would have to be able to survive a high-level bombing attack. To accomplish these objectives, French



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This port view of the Dunkerque also shows the compactness of the design. One of the recognizable features of this ship in comparison to the Strasbourg was the one-level bridge. (Musées de la Marine)



The Strasbourg is shown here at high speed. This ship featured a two-level bridge—one for flag use. This battlecruiser could also be termed a “small displacement battleship,” since she was more heavily protected than her sister ship. With an armament of 330-mm guns, dual-purpose 130-mm guns, good armor protection, and a torpedo defense system with a maximum breadth of seven meters, she was one of the most powerful battlecruisers ever built. (Musées de la Marine)

TABLE 2-3

Design Parameters for a 25,000-ton Croiseur de Combat

Standard displacement	25,000 tons (25,401 mt)
Armament	
Main	13" (330-mm) guns in two quadruple turrets forward of the superstructure.
Secondary	5.1" (130-mm) dual-purpose guns.
Protection	
Armor	The armor system should be capable of resisting the German 11" (280-mm) gun at normal battle ranges. The horizontal armor protection should resist a 1,102-pound (500-kilogram) bomb dropped from 9,842' (3,000 meters).
Torpedo	Protection to be based on a 660-pound (300-kilogram) charge in contact with the ship at a distance of 11.48 feet (3.5 meters) below the design waterline.

naval authorities advocated a deep side protection system, a dual-purpose secondary armament, and an armor system capable of meeting the protection requirements outlined by the Conseil Supérieur. To assist her in her new role, she was to be the first battleship or battlecruiser designed from her inception to carry aircraft.

On 27 April 1932, the Conseil Supérieur met and finally approved the construction of a new battleship to be named the *Dunkerque*, with the characteristics summarized in Table 2-4.

The *Dunkerque* had been approved by the French Parlement in 1931 to counter German armored ships then under construction. Parlement had vigorously opposed the construction of new battleships; funds were cut in mid 1931, and the construction had to be postponed. French parliamentarians could not rationalize why it was necessary to counter a 10,000-ton ship with one of 26,500 tons or why the government was

TABLE 2-4

Final Design Characteristics—Dunkerque

Standard displacement	26,500 tons (26,925 mt)
Full-load displacement	35,697 tons (36,270 mt)
Waterline length	685.70' (209.00 m)
Beam	101.97' (31.08 m)
Draft	31.59' (9.63 m)
Armament	
main	Eight 13"/52 (330 mm) quadrupled
secondary	Sixteen 5.1"/45 (130 mm)—12 quadrupled, 4 paired
antiaircraft	Eight 37 mm—paired Thirty-two 13.2 mm—quadrupled
Shaft horsepower	103,860 (105,300 mhp)
Maximum speed	29.5 knots
Protection	
side belt	9.84" (250 mm) vertical (later sloped)
upper armor deck	5.12" (130 mm)—machinery 5.51" (140 mm)—magazines
lower armor deck	1.77" (45 mm)
slopes	2.17" (55 mm)
torpedo	To resist a contact explosion of 660 lbs (300 kg) of TNT

unwilling to wait for the outcome of the 1932 Disarmament Conference. Finally in December 1931, after much debate, funds were approved to construct the *Dunkerque*. In 1934, when Mussolini announced that two new Italian battleships would be laid down, funds were appropriated for a sister ship to the *Dunkerque*, the *Strasbourg*. The latter was to be identical in many respects, but studies of the armor protection had indicated the need to increase the main side-belt protection. Finally on 2 January 1935 France renounced the terms of the Washington Treaty and followed the example of Japan, so that Treaty restrictions no longer restricted the size of the French battle fleet. In December 1935 a naval conference was held in London with American, British, French, Italian, and Japanese representatives. The latter two withdrew from the discussions before the London Naval Treaty was signed in March 1936 by the remaining parties.

The *Dunkerque* and *Strasbourg*, hereinafter referred to as battlecruisers, carried a number of different designations. The French Parlement called them battleships, battlecruisers, armored ships, or armored cruisers, but the navy always called them battleships (*batiments de ligne*).

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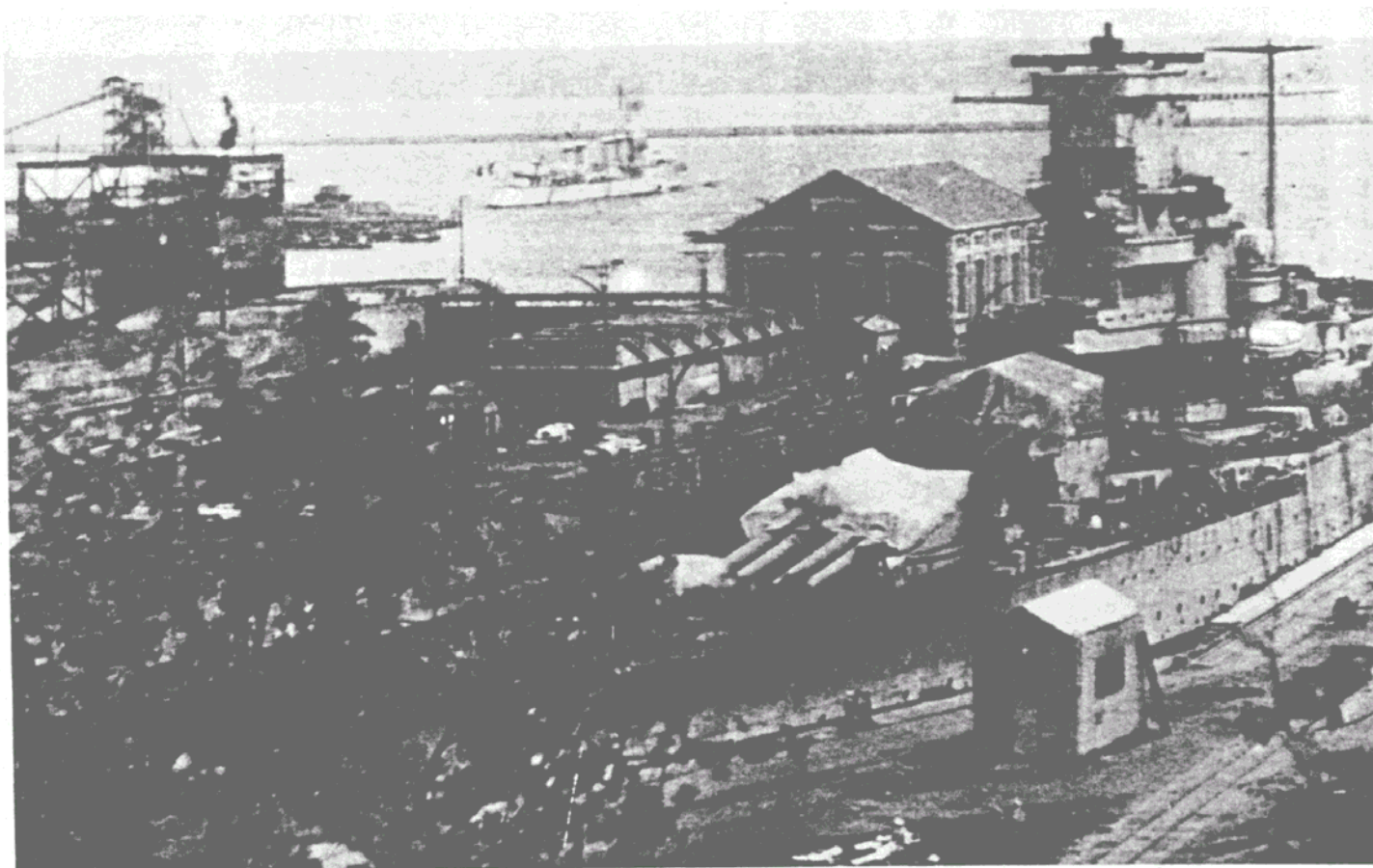
Dunkerque—Operational History. The *Dunkerque*, the first French capital ship to be constructed since World War I, was approved by the Parlement on 19 July 1931. She was built at the Brest Navy Yard, where the keel was laid on 24 December. As the Salou Drydock was too small to accommodate the entire hull, it was necessary to build her with a small portion of the bow missing. On 2 October 1935 the hull was floated to the Laninon Drydock, where a substantial bow assembly was added. The ship was commissioned on 1 February 1936; preliminary and final acceptance trials were conducted in May.

On 1 May 1937 the *Dunkerque* officially became part of the French Fleet and later that month flew the flag of Vice Admiral Devin. On 17 May she left Brest for Spithead to take part in the naval review for the coronation of King George VI of the United Kingdom. She returned to Brest, and then in 1938 cruised to the West Indies and Dakar. She then joined the French Atlantic Fleet, and became the flagship of Vice Admiral Gensoul on 1 September 1938.

On 14 April she left Brest with a special squadron of cruisers and destroyers to cover the return to France of the training cruiser *Jeanne d'Arc* from the West Indies. International tensions had risen over the Czechoslovakian problem, and German armored ships were off the Spanish coast.

In May 1939 she was in Brest for the reception of the British Home Fleet and later in the month left for joint exercises of the French Atlantic Fleet and the British Home Fleet, returning to Brest in June. In July, Vice Admiral Gensoul shifted his flag to the *Strasbourg*. In August, the ship was placed on war alert and on 2 September left Brest to cover the passage to Casablanca of the cruiser-minelayer *Pluton* and the passage from Brest to Martinique of the cruiser *Jeanne d'Arc*. On 6 September she returned to Brest to participate in the search for the liner *France*. During this search, one of her Loire 130 seaplanes was lost and another damaged.

With the commencement of World War II, the French Atlantic Fleet was reorganized into several raiding forces. The *Dunkerque* and *Strasbourg* were in the 1st Line Division (*1ère Escadre de Ligne*) with three cruisers and eight destroyers of the most modern construction. These raiding forces were organized exclusively to intercept German armored ships—two of which were known to be at sea—but they could also be used to escort important convoys in an area from Ushant to the Azores and from the Cape Verde Islands to Cap des Palmes (Gulf of Guinea).



The Dunkerque is shown completing in Brest. The 330-mm guns have been installed, and work is in progress to complete the turret machinery. (Musées de la Marine)

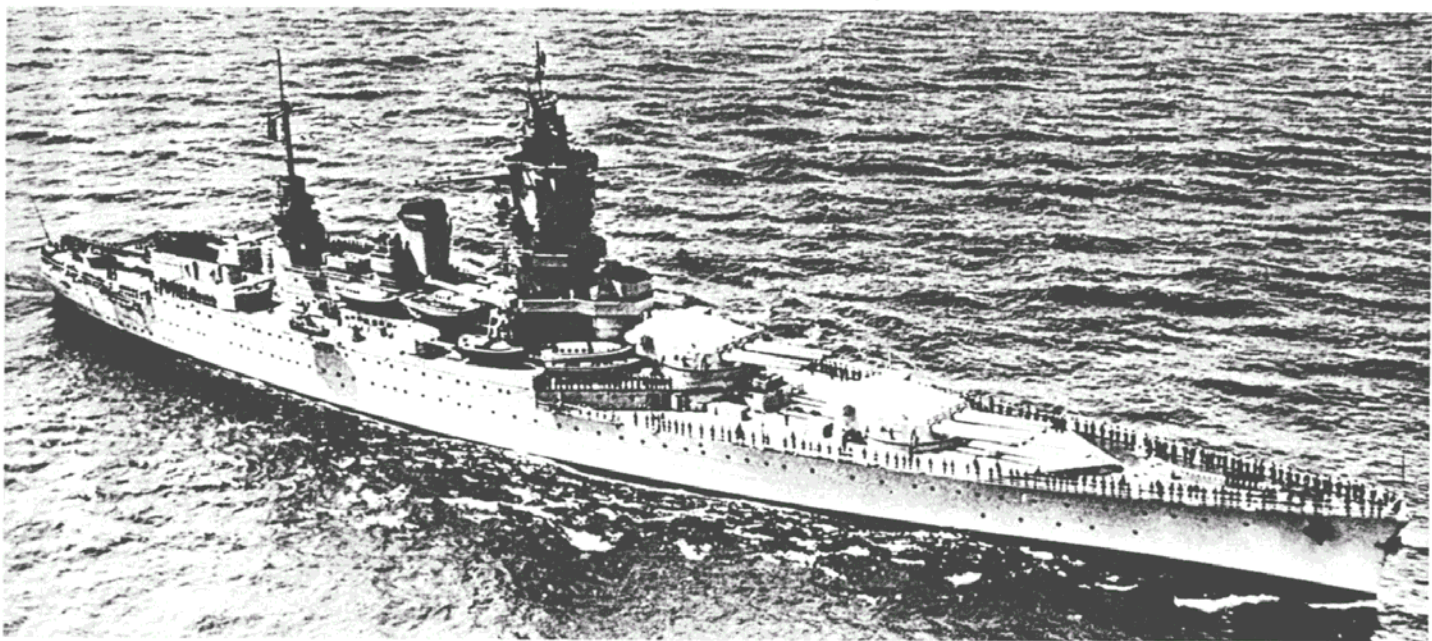
In October the raiding force was reduced to the *Dunkerque*, three cruisers, and eight destroyers. The *Strasbourg* had been assigned to a separate raiding force. There was a report that the German armored ship *Deutschland* might intercept convoy KJ 3 from Kingston, Jamaica. The French raiding force put to sea on 22 October and escorted the convoy to safety. The *Dunkerque* was back in Brest three days later.

On 25 November the *Dunkerque*, in company with cruisers *Georges Leygues* and *Montcalm* and eight destroyers, left Brest to join up with a British Force—which included the battlecruiser *Hood*—to hunt for the *Deutschland*, reported to be in the North Sea. In fact, the ships that this British-French Fleet were searching for were the *Scharnhorst* and *Gneisenau*, who had sunk the auxiliary cruiser *Rawalpindi*. At 1600 the *Hood* and her four destroyers joined up with the French ships off Land's End. The operation took place in very severe weather, and the *Dunkerque* experienced leaks in her forward compartments from the heavy seas. She also had trouble with her anchors due to storm damage to the shell plating, and speed was reduced at one instance to 10 knots. After four days of searching for the Germans, the fleet called at Belfast to refuel. On 30 November German ships were reported to be north of 65 degrees north latitude, and the combined force headed northward. The search was finally called off at 1545, and the *Dunkerque* returned to Brest.

During December 1939 the French battlecruiser delivered a large consignment of gold to Halifax, Nova Scotia. On 22 December, in company with the French cruiser *Gloire* and the British battleship *Nelson*, she left Halifax to escort a Canadian troop convoy bound for the United Kingdom and then returned to Brest.

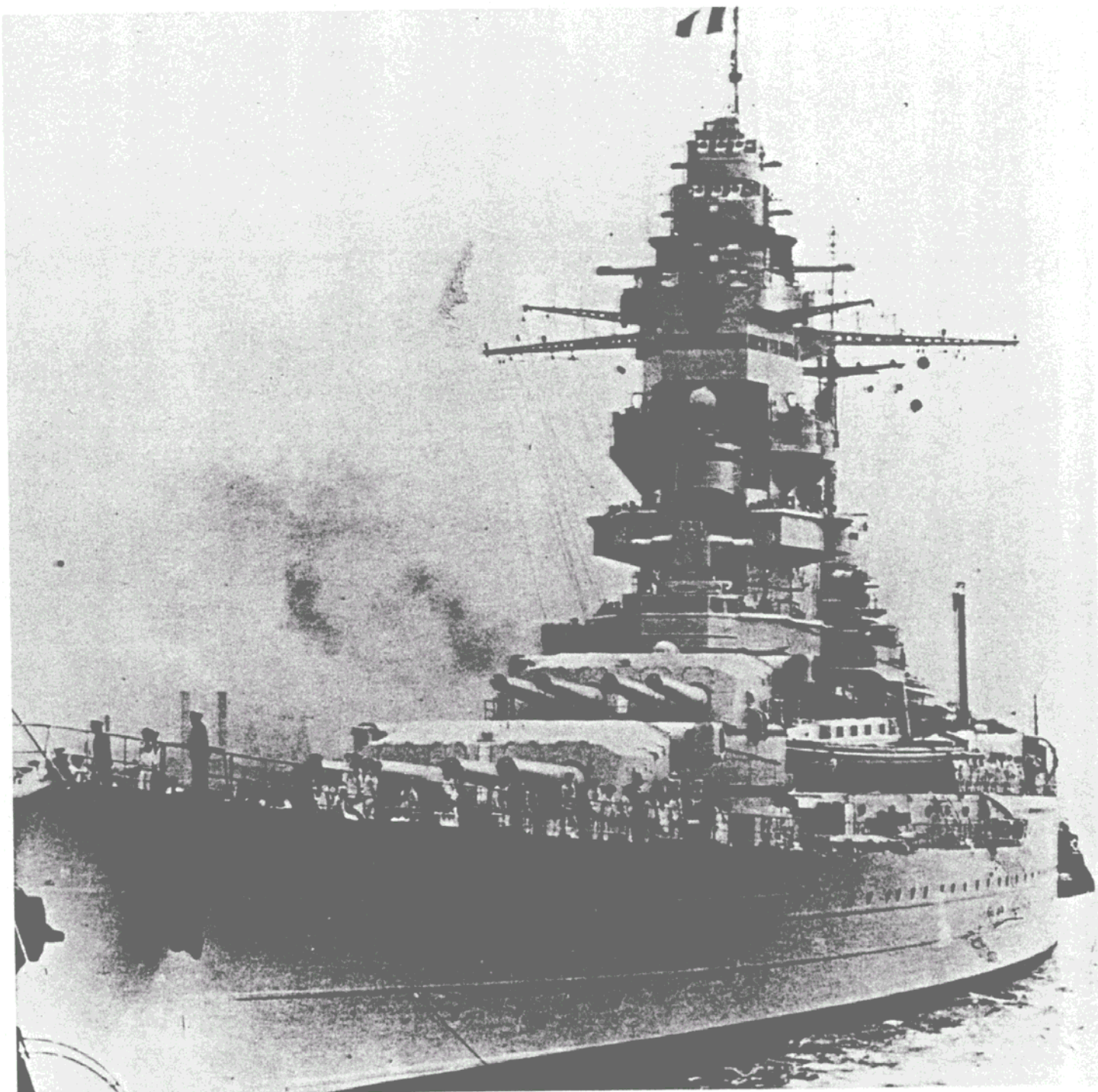


The Dunkerque, the flagship of the French Atlantic Fleet, is shown preparing for the Coronation Review for King George VI in May 1937. (Imperial War Museum)



The crew is at quarters in this pre-World War II photo of the Dunkerque. Note the boat stowage and the secondary battery of twin and quadruple 130-mm guns. The standard displacement of 26,500 tons was achieved through a high degree of concentration unlike that of any other modern capital ship.

During the early months of 1940 the *Dunkerque* was stationed in Brest, but due to a threat of war with Italy, the French Admiralty decided to send the *Dunkerque* to Mers el Kébir, which was considered better suited for fleet operations against the Italians than Brest. There was no action in African waters, however, and she returned to Brest for duty in a proposed Anglo-French operation in Norway. When the Germans invaded Norway, the operation was canceled and the French Admiralty returned the *Dunkerque* and *Strasbourg* to Mers el Kébir to counter any Italian threat in the Mediterranean.



The Dunkerque arrives at Halifax, Nova Scotia, on December 17, 1939, delivering a large consignment of gold for safekeeping. This gold was later shipped to the United States.

On 11 June 1940 Italy declared war on France. On 23 June some French cruisers were covering a convoy between Oran and Marseilles when four Italian cruiser divisions under the command of Admiral Sansonetti tried to intercept them near Minorca. The *Dunkerque* and *Strasbourg* left Mers el Kébir, while a cruiser division was despatched from Algiers. The Italian ships, pursued by the French Fleet, headed for their

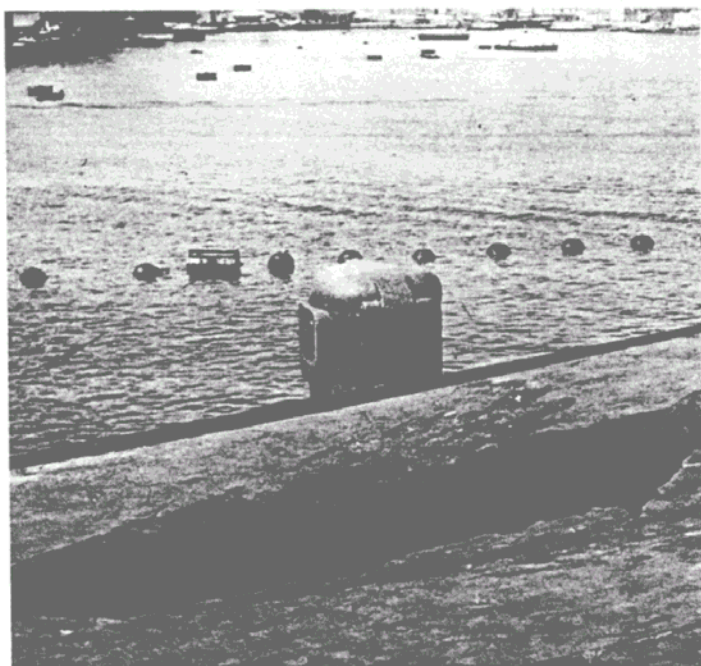
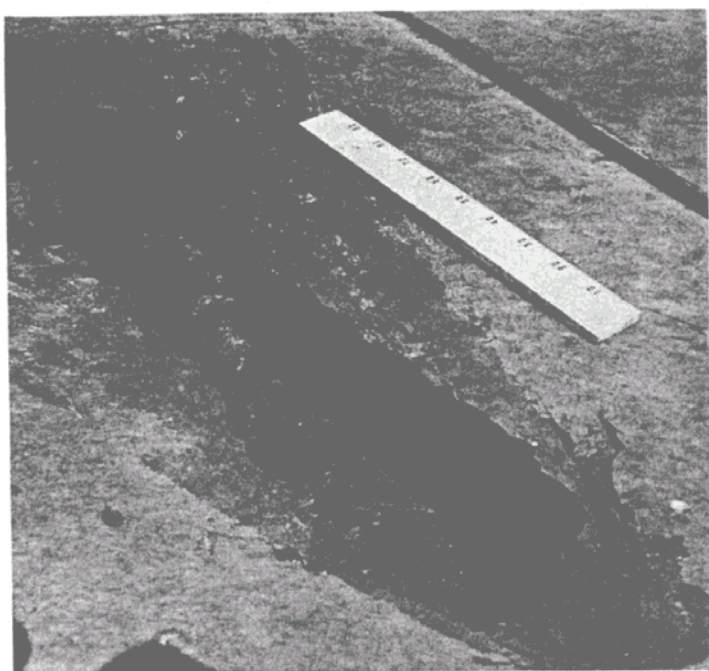
bases. Range could not be closed and the pursuit had to be called off. The *Dunkerque* and *Strasbourg* returned to Mers el Kébir and were in this Algerian anchorage when the Armistice with the Germans and Italians went into force at 0030 on 25 June 1940.

At the end of June, the two battlecruisers were joined by the old battleships *Provence* and *Bretagne*, four destroyers, and a seaplane tender. These ships began to demobilize their crews and prepared to disarm according to conditions of the Armistice.

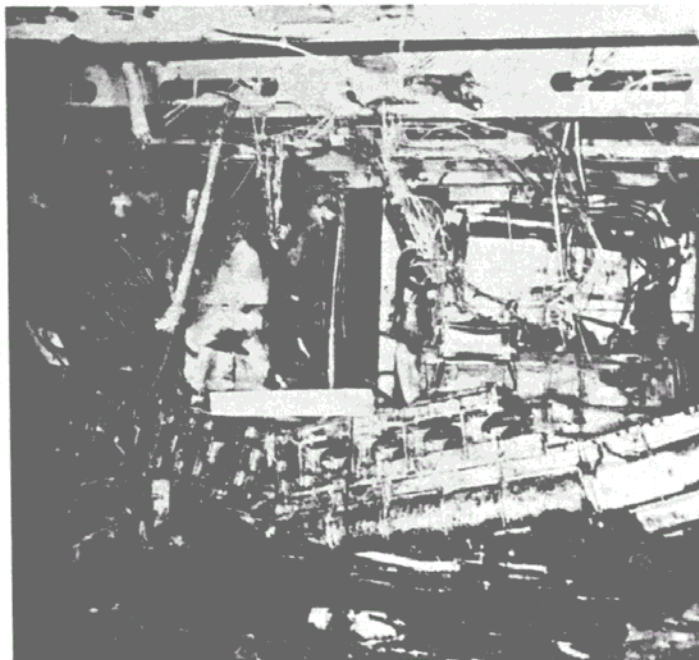
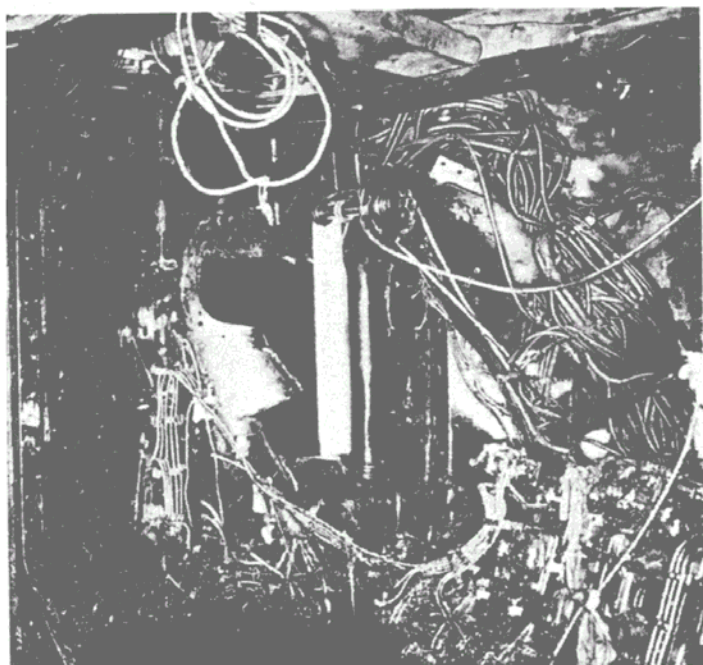
Battle of Mers el Kébir. On 3 July 1940 Force H, consisting of the battlecruiser *Hood*, battleships *Resolution* and *Valiant*, aircraft carrier *Ark Royal*, light cruisers *Arethusa* and *Enterprise*, and eleven destroyers, appeared off Mers el Kébir. At 0724 the destroyer *Foxhound* sent an emissary, Captain C. S. Holland, to the *Dunkerque* to negotiate a settlement with Admiral Gensoul on the disposition of the French ships in this African port. The ultimatums he presented led to a stalemate.

The British feared that the French ships might fall under Axis control. Admiral Gensoul stated that he was not in a position to surrender his ships, as such a decision would have to be made by Admiral Darlan in Paris. He further assured Captain Holland that "force will be met with force" and that if his ships were in danger of capture by the Germans or Italians, he had specific orders from Admiral Darlan to scuttle them. The conferences were divided into two sessions—one in the morning conducted by an intermediary, and one in the afternoon conducted aboard the *Dunkerque* in the presence of Admiral Gensoul and his staff. In the meantime, demobilization measures were halted, and preparations for taking the ships to sea had begun. This included preparation for battle if the need arose. About 1330 five magnetic mines were dropped in the main channel by British aircraft, making negotiations even more difficult, as the French naturally considered this a hostile act. At 1600 Captain Holland came aboard the *Dunkerque* to discuss the situation, which could terminate in hostilities. However, Admiral Gensoul remained adamant. He would not accept the British proposals. At 1725 local time, the talks were broken off, and Captain Holland left the *Dunkerque*. The stage was now set for the first confrontation between British and French warships since 1815.

During his talks with the British emissary, Admiral Gensoul indicated that crews would be reduced, but the ships would have to remain in Mers el Kébir. These talks were also complicated by the fact that the French Navy's main headquarters was being moved that very day, and direct communication with Admiral Darlan was not possible. In any event, Admiral Somerville was growing impatient, and he finally signaled that fire would commence at 1730 unless the British terms were accepted. After Captain Holland had disembarked from the *Dunkerque*, orders were issued to prepare to fire. At 1754 the British ships, which were some 14,000 meters from the French ships, opened fire. The *Resolution's* first salvo hit a breakwater, showering stones and shell fragments on the French ships, which at 1757 returned the fire. The *Dunkerque* was in the process of loosening her mooring lines and slipping her stern chain when a salvo of 381-mm shells hit the breakwater. A tug which was assisting the battlecruiser from her anchorage had to cut her mooring lines when a second salvo of 381-mm shells hit the jetty. At this time, the captain of the *Dunkerque* ordered the immediate emptying of the aviation gasoline tanks and at 1800 gave orders to the main battery to commence fire. The 130-mm guns were also in action against British spotting aircraft. At this instant the old battleship *Bretagne* was hit, and at 1803 the *Provence* was struck by a 381-mm shell. By 1807, *Bretagne* was aflame from bridge to stern, and two minutes later the old battleship began to capsize, when suddenly she exploded. Meanwhile, the *Strasbourg* was heading for the main channel at 15 knots, and the *Hood* concentrated her fire on the *Dunkerque*, which was the nearest to her.



While at Mers El Kébir on 3 July 1940, the Dunkerque was shelled by the HMS Hood. These are two views looking forward of the shell damage to Turret II. A 381-mm shell fired by the British battlecruiser struck the 150-mm-thick roof with a shallow trajectory and gouged into the armor plating before it exploded. Part of the shell entered the starboard gun chamber, starting a fire and killing the entire gun crew on that side of the turret. (Centre Archives de l'Armement)



Another 381-mm shell from the Hood pierced the 115-mm armor deck near the centerline of the starboard 130-mm twin turret, passed through the shell handling room for this turret, and exploded in an air-conditioning machinery room inboard. The photo on the left shows the damage to the shell handling room, while the photo on the right shows some of the damage caused by the shell's explosion inboard. (Centre Archives de l'Armement)

Shell damage. The *Dunkerque* fired forty 330-mm shells at the *Hood* before a cease-fire was ordered at 1810. Because her fire was so accurate and rapid and the *Strasbourg* stood at the entrance of the harbor's main channel, the British ships were forced to maneuver westwards under a smokescreen. Fire from the shore batteries was also becoming effective around this time. The *Dunkerque* was also now under way at a speed of 12 knots, but rangefinding was difficult due to the terrain and the fact that Fort Santon was situated between her and the British ships. Just as she began her turn, the first 381-mm shell from the *Hood* struck aft, passing through the seaplane hangar and a petty officer's space and exiting through the shell plating, 2.5 meters below the waterline. This shell did not explode, because the light plating it passed through was insufficient to detonate the fuze. In its trajectory through the *Dunkerque*, however, the shell severed some port-side electrical circuits and disabled the motors for the airplane crane. Minor flooding occurred in a port-side fuel oil tank.

Shortly after the *Dunkerque*'s captain had given the order to proceed into the channel, she was hit by a salvo of three 381-mm shells. The first of these struck the roof of Turret II over the gunport of the outer barrel and gouged the armor severely. Most of the shell ricocheted and fell to the ground some 2,000 meters from the *Dunkerque*. A piece of armor or a portion of the projectile struck the loading platform in the gun chamber, setting fire to the first two quarters of powder bags in the process of being unloaded. The smoke and fire asphyxiated or burned to death the entire gun crew in the starboard half turret. The port half of Turret II continued in action; the armored partition between the two gun chambers isolated the damage, smoke, and fire.

The second 381-mm shell struck inboard of the 225-mm armor belt's top and pierced the 115-mm armor deck near the centerline of the starboard twin mount. The shell severely damaged the ammunition-handling room for this mount and jammed its hoist. It continued its trajectory inboard, passing through two splinter bulkheads and exploding in an air-conditioning and fan room. This space was totally destroyed, and all personnel in the space were either killed or severely maimed. In the meantime, several cartridges caught fire in the starboard handling room. Several 130-mm shells which were in the process of being loaded into the hoist exploded and killed all personnel within this space.

The explosion also took place near an airduct to the forward engine room for the outboard shafts. Hot gases, flames, and a thick yellow vapor entered the engine room through an armored grating in the lower armor deck and killed twenty men who were at work around the generators and steam turbines. Ten other engine-room personnel managed to escape. All machinery in this space was put out of action. Since it resulted in the disruption of electrical power, this hit was very serious. It crippled the gun-control system and meant that the undamaged 330-mm turret had to continue in action under local control.

The third projectile had a slight underwater trajectory, dived under the 225-mm armor belt, and pierced all structure between the starboard side shell and the torpedo bulkhead before exploding on contact with the torpedo bulkhead. This shell's oblique

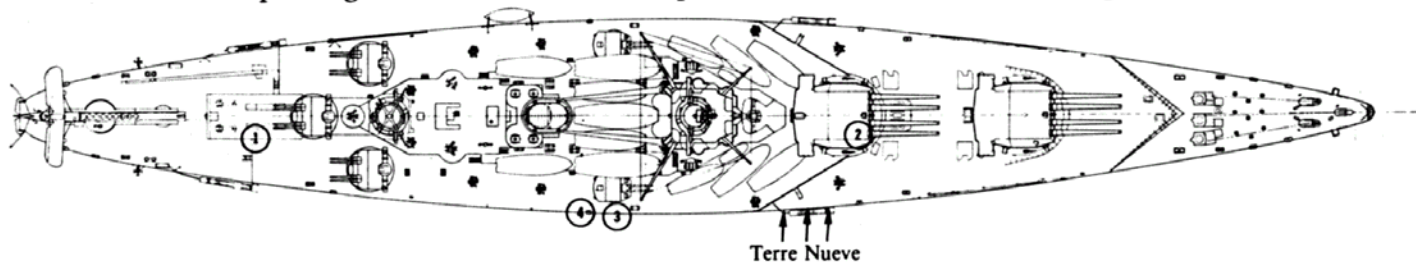


Figure 2-1. Location of 15" shell hits on *Dunkerque*, 3 July 1940.

path managed to carry it through sections K and L, which housed the engine room for the outer shafts and a boiler room immediately aft. The explosion destroyed the lower armor deck in that section of the ship, the lower armor slope over an oil tank, the torpedo bulkhead, and the starboard wire and pipe tunnel. The splinters from the shell started a fire in the duct of the starboard boiler of Fireroom 2 and damaged the burners so that they could not be secured. Some valves for the starboard piping were also damaged. Splinters also severed the main steam line between the boiler and turbines, and superheated steam began to fill the fireroom. Personnel in exposed locations were scalded to death.

Only the after engine room and the boiler room immediately forward continued to operate after these hits. Since power was restricted to two shafts, the maximum speed was limited to 26 knots. The severing of cables on the starboard side caused a momentary disruption of power aft until port-side circuits could be activated. This forced a shift to manual steering. With one of the main electrical stations out of action, the circuits to the diesel generator room forward were activated. Emergency lighting went on, and Turret I continued in action against the *Hood*.

The state of the *Dunkerque* was such that she could no longer go to sea, and at 1810 Admiral Gensoul ordered the captain to halt his port turn into the main channel and to proceed to the harbor of St. André, where Fort Santon and the terrain would provide some protection for this badly damaged ship. With the *Bretagne* sunk and the *Provence* silenced, the British ceased fire at 1812. The *Dunkerque* arrived at St. André around 1813, where she dropped anchor in 15 meters of water.

At 1813 the situation on board the *Dunkerque* was as follows:

- Turret III (starboard 130-mm mount) was out of action because of a fire in its ammunition-handling room. All the crew in the space were dead.
- The electrical circuits on the starboard side were severed. Damage-control and repair parties were attempting to restore power by energizing alternate circuits.
- Forward engine room and its boiler room were out of action.
- The ammunition hoist for Turret IV (the port 130-mm mount) was out of action.
- The direction of Turret II could be manually controlled, but it had no power.
- Turret I was intact and was being fed power from the 400kw diesel generators.
- The hydraulic machinery for opening and closing the armored doors was out of action due to shell damage to the valves and accumulator tank.
- The rangefinders for the 330-mm and 130-mm guns were out of action due to the power failure.

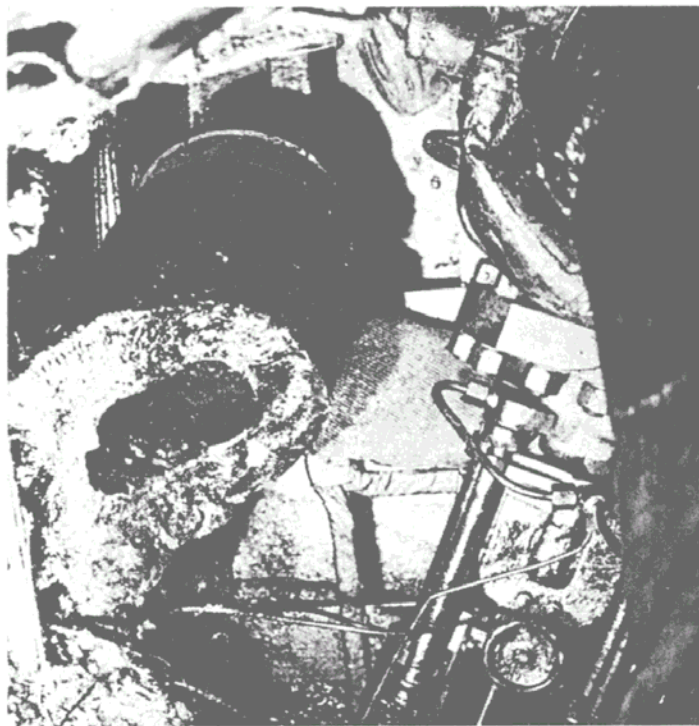
The intrusion of smoke into Turret IV (the port twin 130-mm turret) forced the sealing of the forward 130-mm magazines at 1801. Further explosions took place in the ammunition hoist of Turret III around 2000. Fortunately, the *Dunkerque* was still in Mers el Kébir, because the damage was very serious and would have made it difficult to continue fighting effectively. With the ship unable to maintain her full fighting power because of the loss of motive power on the outboard shafts, the reduction in electric current brought about by the damage to the forward engine room, the difficulty of access into and out of the armored portions of the ship, the loss of the hydraulic machinery room, and no rangefinding capability, Admiral Gensoul decided not to take the *Dunkerque* to sea and ordered the captain to ground his vessel. Before the grounding, the shell hole in section K, which had caused the flooding of some fuel tanks and void compartments, was sealed. Evacuation of all nonessential personnel began immediately, leaving a minimum crew of some 400 men to carry out damage control and cleanup. Around 1900 the tugs, *Esterel* and *Cotentin*, and the patrol boats,

Terre Neuve and *Setoise*, towed the battleship towards shore where she went aground in 8 meters of water. The battlecruiser came to rest on the seabed for some 30 meters along her center section.

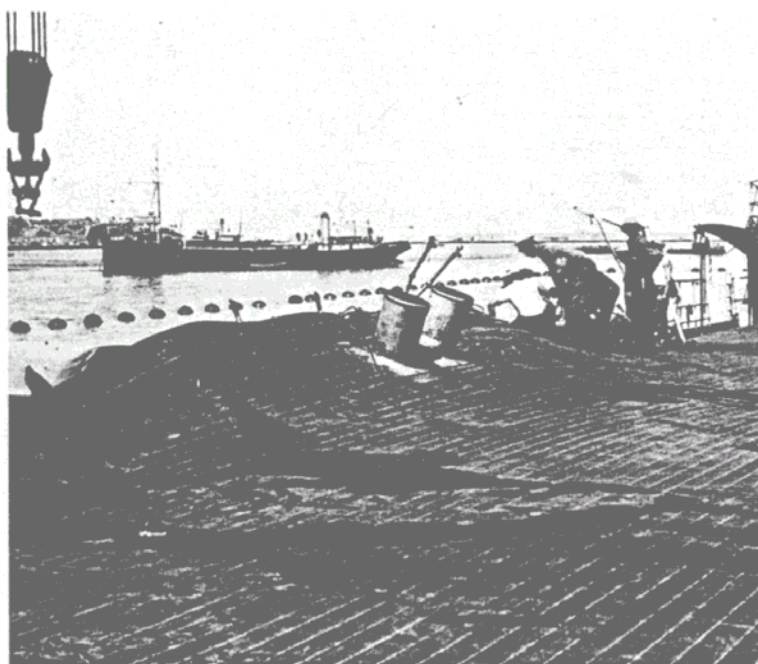
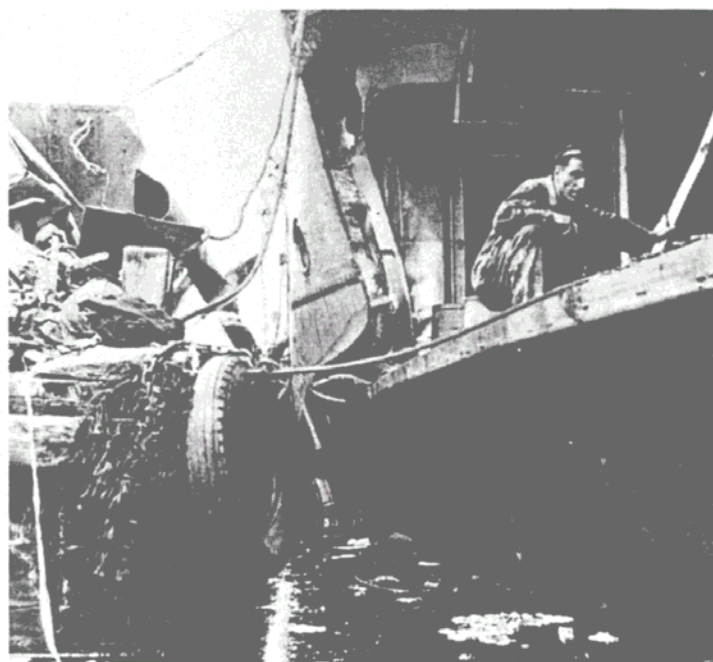
For the 400 that were to remain on board, it was to be a difficult period. Work on a cofferdam was begun in the area where the shells had penetrated the hull plating. Electric power was fully restored, and the grim job of locating and identifying dead comrades began.

Torpedo damage. On 4 July, Admiral Estéva, commander in chief of French naval forces in Northern Africa, stated in a press communiqué that "damages of the *Dunkerque* are minor and will be quickly repaired." This imprudent statement was to bring another swift response from the Royal Navy. During the evening of 5 July Force H, which had returned to Gibraltar on 4 July, went to sea but minus the *Resolution*. Admiral Somerville decided to use the aircraft from the *Ark Royal* to attack the *Dunkerque* instead of engaging in another gun battle. On 6 July the *Ark Royal*, 90 miles off Oran at 0520, launched twelve Swordfish torpedo bombers and twelve Skua fighters for a torpedo attack on the beached French battlecruiser. Torpedoes were set to run at 27 knots and at a shallow depth of approximately 4 meters. Antiaircraft defenses in Mers el Kébir were not prepared for an early-morning attack, but soon after the first wave of British aircraft attacked the *Dunkerque*, antiaircraft fire became more intense. This was followed by French fighter plane intervention.

The captain of the *Dunkerque* had decided to evacuate the antiaircraft crews and leave only personnel from the repair parties on board. The patrol vessel *Terre Neuve* was alongside taking aboard some of the crew members and embarking the coffins of those who had died in the 3 July debacle. This was still in progress when the British planes attacked at 0628 in three waves. Two planes in the first wave prematurely



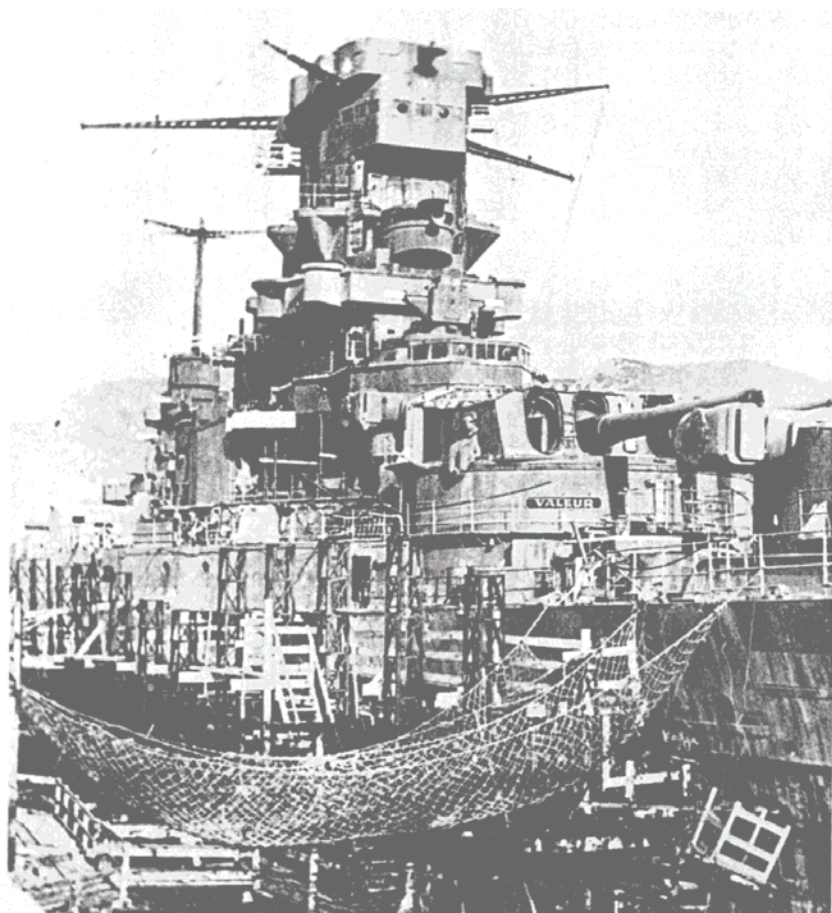
This damage to a petty officer's stateroom was caused by another 381-mm shell which passed through the hangar and exited through the shell plating below the waterline. (Centre Archives de l'Armement)



These four views show damage caused by the explosion of a torpedo and depth charges near the Dunkerque on 6 July 1940. The top photos show a closeup of the damage to the side shell plating outboard of Turret II. (Centre Archives de l'Armement) The lower left photo was taken aboard the ship looking to starboard and shows the damage to the main deck over the hole caused by the detonation of the equivalent of some 6,000 pounds of TNT! Note that the French have placed a torpedo net around the ship. (Centre Archives de l'Armement) The lower right photo was taken shortly after the torpedo attack by aircraft from the British aircraft carrier Ark Royal. In the foreground is the mainmast of the patrol boat Terre Neuve which was also sunk during the same attack. A torpedo passed under the keel of the Dunkerque and struck the stern of the patrol boat which had a full load of some forty-two depth charges. Their explosion ripped a hole in the side of the Dunkerque abreast of Turret II. The underwater protection system performed beyond expectations, and no flooding was incurred in compartments inboard of the torpedo bulkhead. (Musées de la Marine)

launched torpedoes which harmlessly exploded against a jetty. The third torpedo, launched for a clear run on the *Dunkerque*, failed to explode. About 0647 the second wave of torpedo bombers closed the *Dunkerque*. Three more torpedoes were launched, but none hit the *Dunkerque*. One, however, did hit the *Terre Neuve* which was just leaving the battlecruiser. The torpedo exploded and literally cut the little craft in two. The small ship's superstructure disintegrated and debris was showered down on the *Dunkerque*. Six more Swordfish torpedo bombers with Skua fighter support arrived around 0650. The starboard flight was heavily attacked by French fighters and intense anti-aircraft fire. No hits were scored. The last subflight of three planes attacked from the port side. Two torpedoes approached the *Dunkerque* diagonally from her port bow. One struck the tug *Esterel*, lying some 70 meters from the side of the battlecruiser, and literally blew her out of the water. The second evidently passed under the keel of the *Dunkerque* and struck the stern wreckage of the *Terre Neuve*, detonating her load of forty-two 100-kilogram depth charges even though the detonators had been removed. That explosion tore a hole in the *Dunkerque* for 40 meters along her starboard side. Several main side-belt armor plates were displaced, and water poured into the side protection system. The force of the explosion ripped apart the steel plate above the armor belt, and it fell to the deck of the *Dunkerque*, burying some people in the area.

The torpedo bulkhead had tears in its plating for a length of 40 meters. Watertight bulkheads within the side protection system were ripped open or deformed. A starboard list developed, and the ship settled by the bow to a draft above the side armor belt. The spaces inboard of the damaged bulkhead were flooded with a mixture of salt water and fuel oil. The ship had 210 casualties from this and the previous attack.



The *Dunkerque* is shown in 1942 at Toulon after she had been scuttled. She was still undergoing repairs in November 1942 from the British shell and torpedo attacks of July 1940, when the Germans invaded the unoccupied portion of France. Note that the 130-mm and 330-mm rangefinders on top of the forward command tower are missing, that damage sustained to the starboard shell plating has been repaired, and that one of the starboard guns in Turret II is missing. (Musées de la Marine)



A spectacular view of the after secondary battery complex on the Dunkerque. A violent explosion, probably of the centerline magazine, completely demolished the centerline turret immediately abaft the director tower. Two 130-mm guns can be seen resting on the deck to the left. The intact starboard wing 130-mm quadruple turret can be seen to the right. (Musées de la Marine)

A temporary patch was fitted over the damaged area, and the ship was refloated on 8 August. Repair work progressed very slowly; she was unable to sail until 19 February 1942. She left secretly. When men reported for work that morning, they found their tools stacked on the quay. The ship reached Toulon at 2300 on 20 February, with some scaffolding from Mers el Kébir still in place. She entered one of the Vauban Docks for final repairs, but because of material shortages these were never accomplished. When the Allies invaded North Africa on 8 November 1942, repairs were still in progress.

Dunkerque scuttled. On 27 November 1942, the French scuttled the *Dunkerque* to prevent her capture by the Germans; they blew up guns and destroyed turbines, range-finders, radio equipment, and optical gear. Control spaces were blown up or wrecked. The ship never sailed again.

Final Disposition. In 1943 Italian salvage teams stripped the ship and sent tons of scrap back to Italy. In order to refloat her and free the drydock, they cut off the damaged bow and floated it out of the dock. The stern section was later damaged by Allied bombing. The Italians were forced to abandon their demolition of the ship, but they had managed to wreck her beyond all hope of repair; they even cut off the barrels of the 330-mm guns. In 1945 French salvage teams removed the remainder of the hull from the drydock, and in 1958 the remaining portion of the ship was sold for 253 million francs (\$723,000).

Strasbourg—Operational History. The *Strasbourg* was built jointly by two St. Nazaire shipyards, Penhoët and Loire.* The keel was laid on 25 November 1934, and the ship was launched on 12 December 1936. She was sent to Brest for final outfitting, commissioning, and trials, and entered active service early in 1939. The *Strasbourg* was similar in appearance to the *Dunkerque*, except that she had a two-level bridge. For identification purposes, the *Strasbourg* had one white band around her funnel, while the *Dunkerque* had two. Internally the ships differed in their armor protection and fuel capacity. The *Strasbourg* had thicker armor on her sides, armored bulkheads, and main turret roofs, and the fuel-oil capacity was increased from 5,775 tons to 6,045 tons. All of these changes meant that the *Strasbourg* had a deeper draft and a somewhat slower speed.

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The *Strasbourg*'s prewar service paralleled that of the *Dunkerque*. On 30 September 1939, the British cargo ship *Clement* was reported sunk by the German armored ship *Admiral Graf Spee*, which was known to be somewhere in the South Atlantic Ocean. The British and French Admiralties decided to form a hunting group to be based in Dakar. On 7 October the *Strasbourg* and two destroyer divisions sailed from Brest and were joined outside the French port by the aircraft carrier HMS *Hermes* and three French destroyers. On 10 October the hunting group, now called Force X, was joined by the cruisers *Algérie* and *Dupleix* and two destroyers. Command of the combined fleet was given to Vice Admiral Duplat, who flew his flag from the heavy cruiser *Algérie*. On 16 October a German cargo ship was intercepted and sunk by gunfire. After returning to Dakar, the Allied force was back on patrol on 23 October. On 25 October the German cargo ship *Santa Fe* was captured, and Force X headed for Dakar. Searches for the *Admiral Graf Spee* continued the rest of October and into November, but proved to be fruitless. During the latter part of November, the *Strasbourg* returned to Brest and in December was overhauled in the Brest Navy Yard.

Battle of Mers el Kébir. From January until the Armistice in June 1940, the *Strasbourg* operated exclusively with the *Dunkerque*. On 3 July she was in Mers el Kébir. She had her boilers at steaming level when the British opened fire, and her stern anchor chain freed before the first shells hit the breakwater. She had barely left her berth when a shell landed on the breakwater, and fragments from it cut her halyards and broke the flag staff. Five sailors at the stern were killed. Another splinter passed through the funnel. At 1810 she was in the main channel, followed by six destroyers of the *Fantasque* class. The battlecruiser was able to outrun the 381-mm shells, but the lead destroyer, *Mogador*, was hit just outside the harbor entrance by a 381-mm shell which detonated her load of sixteen depth charges. The destroyer was disabled, but the other five continued on with the *Strasbourg*. The *Lynx* and *Tigre* headed for a British submarine, the *Proteus*, and launched depth charges to prevent her from firing any torpedoes at the *Strasbourg*. Six more destroyers from Oran would later join up with this group off Cape Canastel and head east.

The unexpected appearance of this French force outside the anchorage, and the intense fire from the *Dunkerque* and the short batteries, had forced the British fleet to move farther offshore. In the process, the British had laid a smokescreen which also hampered their ability to spot the French force speeding eastwards. The British destroyer *Wrestler*, which was guarding the harbor entrance, was confronted with the French battlecruiser at close range and came under heavy fire. By skillful maneuvering, however, she was able to get away unscathed. The *Strasbourg* began to develop her

* These two shipyards amalgamated in 1955 to form Chantier de l'Atlantique, Penhoët-Loire.

full speed, and just in range to the northwest was the carrier *Ark Royal*. Nevertheless, there was no action taken. At 1945, however, six Swordfish bombers armed with 124-kilogram bombs and escorted by two Skuas from the *Ark Royal* attacked, but scored no hits. The antiaircraft fire was extremely heavy and accurate, one Skua being shot down. Two of the Swordfish planes were badly damaged and crashed into the sea when returning to the *Ark Royal*.

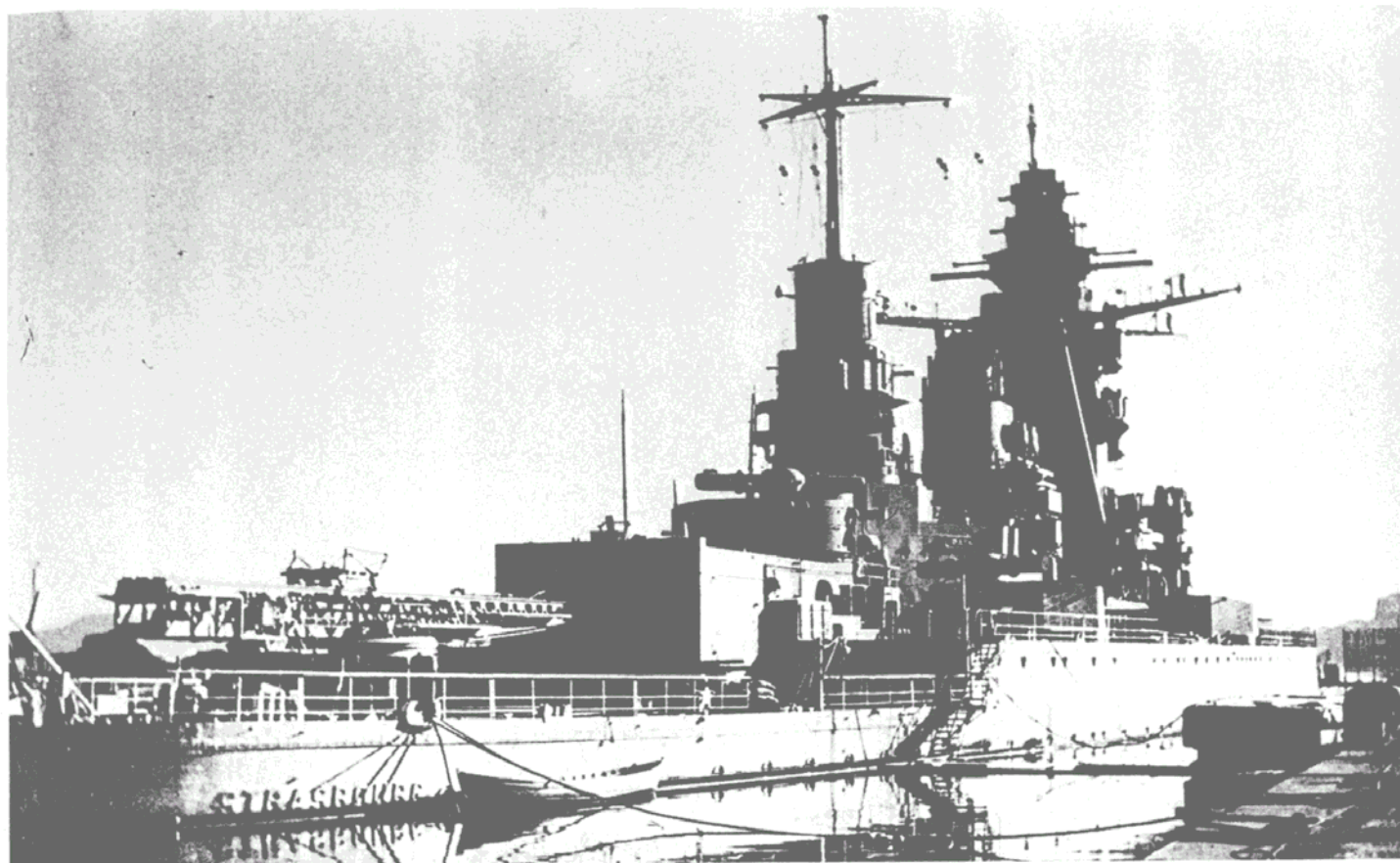
At 1843 Admiral Somerville decided that his flagship, the *Hood*, would take up the chase, as she was the only British capital ship fast enough to overtake the fleeing battlecruiser. By 2000 that evening, the *Hood* was 44,000 meters astern of the *Strasbourg*—unable to close the range, and silhouetted against a setting sun. Admiral Somerville ordered the *Ark Royal* to make another air attack to slow down the French battlecruiser. At 2050 Swordfish torpedo bombers, despite fierce antiaircraft fire, dropped torpedoes outside the destroyer screen, but all torpedoes missed. The chase had been called off at 2020; British destroyers accompanying the *Hood* were low on fuel, strong French squadrons of cruisers and destroyers were reported en route from Algiers, and darkness had fallen—meaning that a night engagement would have to be fought with a superior French force. Besides, the *Valiant* and *Resolution* were without destroyer escort in now-dangerous waters. The *Strasbourg* continued on at 25 knots until there was an accident in one of her firerooms. This resulted in the death of five stokers and the loss of three boilers, reducing the speed to 20 knots. The damage was repaired within forty-five minutes and the ship was back at 25 knots once again. Only three destroyers were able to keep pace with the battlecruiser, and she safely arrived in Toulon at 2010 on 4 July, having rounded the southern tip of Sardinia to avoid any further confrontations with Force H.

During 1941-42 the *Strasbourg* remained at Toulon and became the flagship of the French fleet based there. She was the flagship of Admiral Gensoul until 8 August 1940 when he became Chief Inspector of the Navy. Admiral de Laborde later made her his flagship. Fuel was scarce, and this limited the battlecruiser to short cruises off Toulon. Ship operation during this period was only one-third or one-quarter that of peacetime.

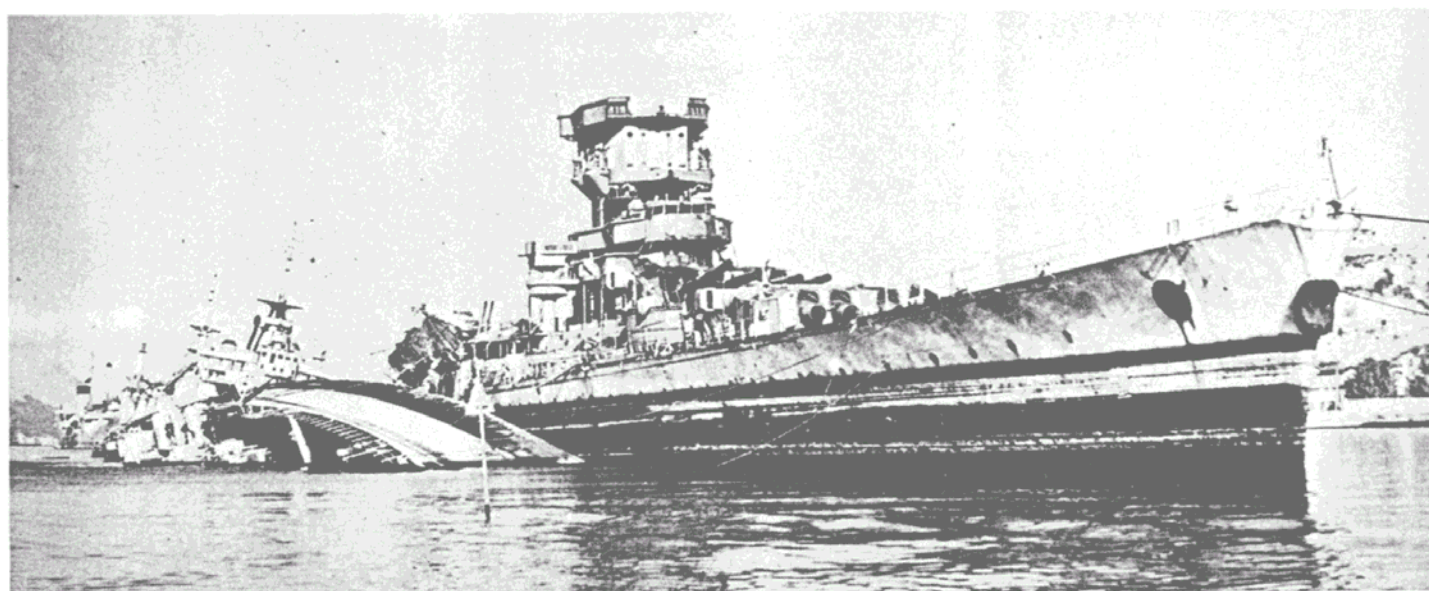
Strasbourg scuttled. On 8 November 1942, the Allies invaded North Africa, and within a few days the French garrisons ceased resistance. All of the French warships based on the African Atlantic Coast also surrendered to the Allies. Hitler ordered the occupation

This bow view of the *Strasbourg*, flagship of the French Mediterranean Fleet, scuttled in Toulon on 27 November 1942, shows that the superstructure remained intact. Explosive charges were set off in her magazines and propulsion plant, and she settled some 12 meters into the muddy seabed. A thick layer of oil surrounded the battlecruiser for weeks. (Musées de la Marine)





A view of the Strasbourg from her starboard quarter, after the ship was scuttled at Toulon to avoid German seizure. (Musées de la Marine)



This starboard view of the Strasbourg hulk shows the damage done by Italian salvage teams to the forward command tower and the main turrets. The four barrels of Turret I were cut off, as well as the rangefinders and the upper bridge tower. The torn plating on the starboard side aft is from a 454-kg general-purpose bomb hit, sustained in August 1944. The opening in the ship was approximately 11 meters long. (Imperial War Museum)

of Southern France in retaliation, although this was a violation of the 1940 Armistice. Early on 27 November, German tanks entered Toulon, and at about 0600 one tank reached the quay where the *Strasbourg* had been moored. Because an order to scuttle all French naval units in Toulon had been issued at 0515, she had already cast off. The tank fired a shell into one of the 130-mm turrets, where it killed an officer and wounded several men who were planting demolition charges. Several minutes later, scuttling charges disabled the turrets and opened seacocks in the engine rooms. The detonations caused bulging in the side shell, and there were numerous tears in the shell plating at or near the operating waterline; flooding followed. The *Strasbourg* sank some two meters into soft mud, but remained upright. Fuel oil from ruptured tanks floated all around her.

Italians strip Strasbourg. On 17 July 1943 Italian salvage teams floated the ship and began to strip her. In March 1944 the German Navy returned her to the French Navy. Unable to rearm or repair her, the French decided to move her into the harbor and put a skeleton crew on board. Later, the Germans removed the French crew and used the hull to block the main ship channel.

Bomb damage. During the Allied invasion of Southern France in 1944, planes of the American 321st Bomb Group, acting on an erroneous report that the ship was preparing for battle, bombed and severely damaged her. The ship had no crew or ammunition, and the Italians had removed the rangefinders. A few Germans on board at the time fired their own light anti-aircraft weapons.

The Americans dropped a total of forty-four 454-kilogram general-purpose and one hundred and eight 454-kilogram semi-armor-piercing bombs. See figure 2-2 for the approximate location of the bombs that struck the *Strasbourg*.

One general-purpose bomb struck the main deck just forward and outboard of the centerline catapult foundation. The catapult itself had been removed by the Italians. The bomb penetrated the upper and main decks before exploding 6.1 meters inboard of the starboard side shell. A hole 7.92 by 3.43 meters was blown out, and shell plates above the hole were buckled. The main deck was pushed upwards over a length of 10.67 meters, and the second deck was dished downwards for a maximum of 17 mm within a circle 3.05 meters in diameter.

Another bomb, probably general purpose, hit on the starboard side midway between the hangar and catapult foundation and exploded close to the second deck. A riveted shell seam was torn open for a distance of 10.61 meters, the upper and main decks were puffed upwards over the area hit, and a number of fittings on the second deck were destroyed or damaged for a distance of 22.86 meters.

Another bomb struck the port side directly opposite that hit, pierced the upper deck, and exploded 2.74 meters from the side and just above the main deck. A riveted shell seam was torn open for 8.69 meters and the upper deck plating was peeled back and puffed upwards around the point of entry.

A semi-armor-piercing bomb struck the port side 4.57 meters inboard of the third hit, penetrated the upper deck, and exploded on contact with a strip of 100-mm armor

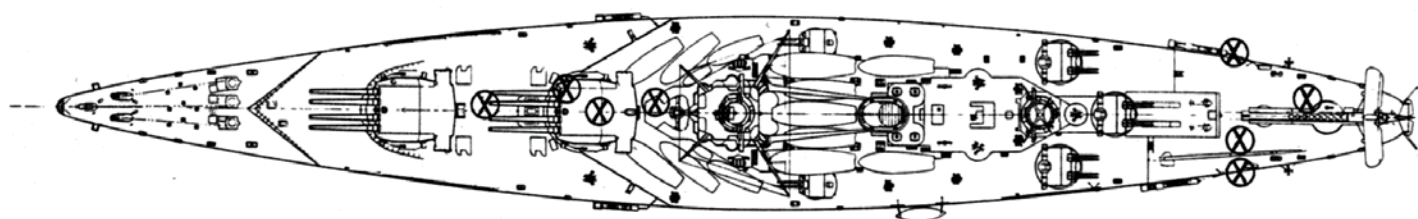
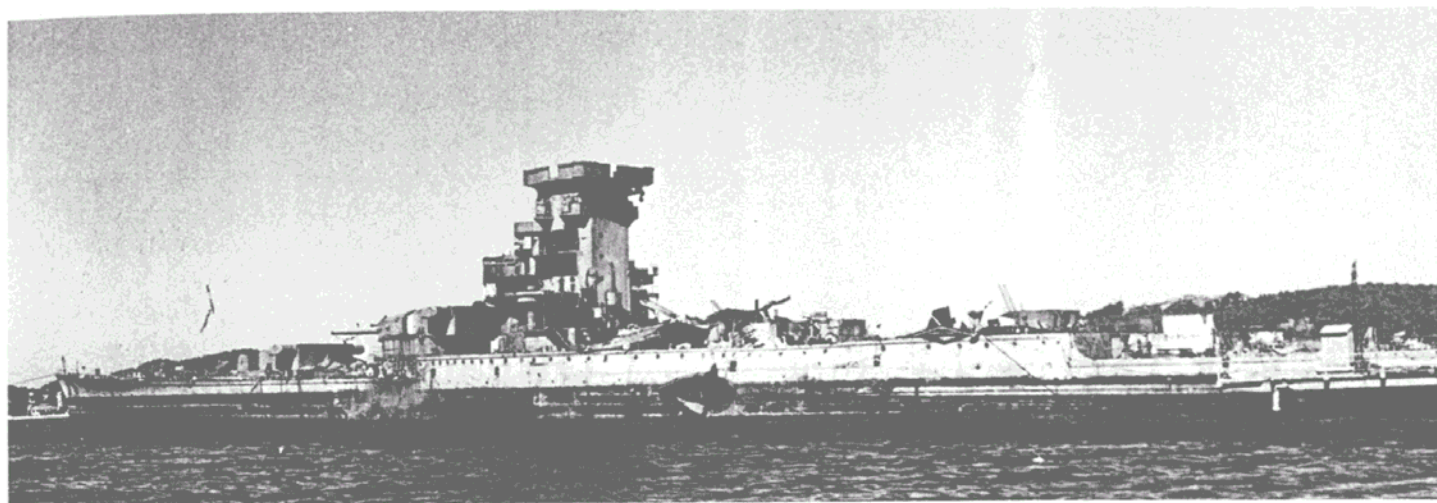


Figure 2-2. This overhead view locates the bomb hits on the battleship *Strasbourg*, August 1944.



This is a port view of the hulk of the Strasbourg after being attacked by Allied bombers near Saint Mandrier during August 1944. A total of 152 bombs were dropped on the hulk and six direct hits were scored. The large hole, abreast of where the funnel was located, resulted from the explosion of a 454-kilogram general-purpose bomb. The Strasbourg had been in the process of being stripped by the Italians until the Germans halted their activities. The black band on the hull above the waterline resulted from fuel oil released from her tanks after scuttling.

plate between the two hatches. The armor failed, and a bulkhead between the two hatches was completely destroyed. The combination of this hit and the previous one severely damaged the outboard compartments. Three banks of electric cables were severed by fragments.

One general-purpose bomb struck near the breech of the outboard gun in the starboard gun chamber of Turret II. At the point of impact the barrel was flattened 51 mm in a circle 0.61 meters in diameter. The inboard gun was gouged and marked by fragments at the point of impact. The effect on the gun's operation was not determined as it was never test fired.

A general-purpose bomb struck the 150-mm armor roof of Turret II, and ricocheting fragments severely damaged the bridge. Another exploded on contact with the lower bridge deck and ripped a hole 1.73 by 1.14 meters in the deck. The housing of a nearby generator was holed by fragments, and several electric cables were severed.

A semi-armor-piercing bomb hit forward of Turret II and slightly to starboard of the ship's centerline, pierced the upper deck and exploded between the main and second decks. The explosion rolled the upper deck plate back from the point of penetration, interfering with training the turret to starboard. There was extensive damage to the main deck bulkheads and fittings over a distance of 15.24 meters.

The *Strasbourg*, seriously damaged, was grounded near Saint Mandrier. The sinking was caused by a near miss which tore the hull open near the waterline. Proper damage control and counter-flooding was impossible, because there was no crew on board. Topsides damage was extensive. If the ship had been fully manned, loss of life would have been heavy. The greatest damage was to structural and electrical systems. The latter would have crippled vital functions such as steering and could have impaired damage-control procedures in certain areas of the ship.

Preinvasion plans to have the ship reconditioned in a U.S. shipyard had to be canceled due to extensive bomb damage. She was refloated in 1946, and the French Admiralty at that time proposed to have the hull converted to a light aircraft carrier. That plan was later canceled due to the lack of funds, and the hull was used in the Bay of Giens near Toulon for underwater explosion experiments.

Final Disposition. In May 1955 the *Strasbourg* was sold for 458 million francs (\$1,208,000) and scrapped in Toulon. She had fired her guns in battle only once.

Armament. Guns mounted on the *Dunkerque* and *Strasbourg* had the characteristics tabulated in Table 2-5.

TABLE 2-5

Gun Characteristics

Gun	13"/52	(330 mm)	5.1"/45	(130 mm)
Shell weight (lbs)	1,235	(560 kg)	70.77*	(32.1 kg)
Muzzle velocity (fps)	2,854	(870 m/s)	2,625	(800 m/s)
Maximum range (yds)	45,600	(41,700 m)	22,770	(20,870 m)
Maximum elevation	35°		75°	
Gun	1.46"	(37 mm)	0.52"	(13.2 mm)
Shell weight (lbs)	1.80	(0.82 kg)		
Muzzle velocity (fps)	2,707	(825 m/s)	2,625	(800 m/s)
Maximum range (yds)	8,300	(7,600 m)	7,850	(7,200 m)
Maximum elevation	80°		90°	

* A 5.1" (130-mm) AA shell weighed 64.9 lb (29.5 kg).

Main battery. The main-battery size was strongly influenced by the German armored ships. At a technical-board conference in 1929, the main battery of eight 305-mm guns, which had been proposed to be increased to 330 mm during the preliminary design, was judged insufficient to meet the requirements advanced by the Conseil Supérieur after evaluating the results of a study made by the Service Technique des Constructions Navales. It was further proposed that the ships should be armed with six 380-mm guns in triple turrets. With the appearance of the German armored ships, however, French naval constructors and ordnance experts decided that the 330-mm gun would be better suited to oppose them, because the development of a workable triple turret with heavy guns was believed to be a long and costly process. A quadruple-turret design could be produced in less time and at reduced costs—particularly since there were drawings available of the 340-mm main-battery turrets of the ill-fated *Normandie* class. Moreover, the adoption of the 330-mm gun offered a more satisfactory balance of speed and protection.

The main battery consisted of eight 330-mm/52-caliber (Mark 1931) guns in quadruple turrets forward of the superstructure. Fire power aft was provided by the secondary battery of 130-mm guns. Although strongly influenced by the British battleships *Nelson* and *Rodney* and the need to save weight, this was one of the most unusual developments in the modern big-gun capital-ship era. The use of quadruple turrets was a bold feature in French battleship design, dating back to the *Normandie*-class ships. Turrets were divided into half turrets, as in that class, and both guns were mounted on the same sleeve within the half turrets.

The main-battery arrangement resulted from technical and tactical considerations, particularly the former. It permitted considerable weight reduction, as shown in Table 2-6.

The triple-turret nine-gun battery showed a 6.74 percent decrease in weight over the twin-turret eight-gun battery, with the added feature that total fire power was increased by one gun. The quadruple-turret arrangement offered a 27.6 percent weight reduction over the twin-turret configuration with the same number of guns—a decid-

TABLE 2-6

Comparison of Twin, Triple, and Quadruple 330-mm Turret Weights

Type turret	Turret weight	Weight per gun
Twin	1,560 tons (1,585 mt)	780 tons (793 mt) per gun
Triple	1,940 tons (1,971 mt)	641 tons (677 mt) per gun
Quadruple	2,260 tons (2,296 mt)	565 tons (571 mt) per gun

ing factor in the selection of a quadruple turret. The gun concentration was better in the twin-turret configuration in that there were four gun positions, but with the use of half turrets and separate magazines, this advantage was also eliminated. The shorter length of the armored citadel resulting from the use of quadruple turrets saved approximately 15 tons per meter; a total weight saving of 125 tons was expected from the use of quadruple turrets in the design of the *Dunkerque*; this was applied to strengthening armor protection of the turrets.

From a tactical consideration, concentrating the main battery forward was the consequence of the preponderant importance of an overtaking action with a 26-knot German armored ship. Ships with a superior armament and speed of almost 30 knots were guaranteed an overwhelming offensive advantage. Higher speed let them choose the time and place of battle. The main battery forward ensured a full broadside at a fleeing armored ship, and would also eliminate the troublesome effects and interference of stack gases. One important advantage of concentrating the main battery forward was the avoidance of the effects of blast from the 330-mm guns in the floatplane launching and recovery area. This equipment and structure was vulnerable to such blast pressures, and eliminating the guns from the stern end meant that lighter weight equipment could be used. Also, the concentration was beneficial to the boat stowage and the placement of lighter antiaircraft weapons in a ship whose weight and space were at a premium.

The centerlines of the 330-mm turrets were located 52.15 meters and 80.95 meters from the forward perpendicular.* The magazines were deliberately spaced 10.1 meters apart, making it difficult for a single hit to damage both turrets or magazines simultaneously. This, in combination with the concentration of the main battery into quadruple turrets, reduced the target offered by the turret grouping and thereby lessened the disadvantage of the main-battery arrangement. To increase the arc of train aft and minimize the unprotected after sector, however, the superstructure was carefully contoured and the turrets given a larger arc of train than most conventional battlecruisers or battleships. Turret I had an arc of train of 286 degrees and Turret II had 300 degrees.

The powerful, long-range guns could fire one round every twenty-two seconds. The armor-piercing shell, with an explosive charge of 19.3 kilograms, could penetrate 300 mm of armor at 28,000 meters. The guns had a range of 23,000 meters at an elevation of 23 degrees and 41,700 meters at the maximum elevation of 35 degrees. They could be depressed to a maximum of five degrees and could be loaded at any angle, as the breech was hydropneumatically operated. The main turrets could train at a rate of 1.5 degrees per second.

Each half turret was serviced by separate sets of shell and powder magazines, each pair on the same deck, powder magazines forward and shell magazines aft, instead of the conventional upper and lower arrangement used on most battleships and battlecruisers. The two pairs were stacked, one above the other, on two decks, each pair

* Intersection of the design waterline with the stem of the ship.

supplying the two guns in a half turret. The unorthodox location of the main battery caused no operational difficulties.

Secondary battery. The secondary battery of sixteen 130-mm/52-caliber (Model 1932) guns had many unusual features. They were the first dual-purpose guns used as a secondary armament in a battleship and battlecruiser, and were specifically designed for these ships. In order to have some armor protection on the secondary turrets and reduce their number without increasing the displacement, the secondary battery was concentrated in three quadruple turrets and two twin mounts.* The use of twelve guns in three quadruple turrets was unprecedented; it was also unsuccessful and not repeated in any of the battleship designs to follow. The quadruple turrets were located in a triangular pattern as far aft as the aircraft-handling equipment at the stern would permit. The twin turrets were located outboard between the funnel and the bridge tower. These guns were also positioned abaft their magazines, and an elaborate hoist system was developed for them. The greatest possible arc of train was provided this battery, because it was recognized that the airplane would become the greatest threat to a capital ship over the life span of these vessels. The lateral quadruple and twin turrets could train 175 and 171 degrees respectively; the after centerline turret, being mounted above the hangar, had a much greater arc of train of 300 degrees. Even so, a small sector forward lacked secondary battery coverage, as was the case in most modern capital ships.

The secondary battery guns could fire ten to twelve rounds per minute. Maximum range was 20,800 meters at a 45-degree elevation. The guns could be depressed to 10 degrees and elevated to 75 degrees; elevation rate was 6 degrees per second. The quadruple turrets were divided into two separate gun chambers, with two barrels fitted to a single sleeve for two-shell salvo fire. Although 130-mm (Model 1924) guns were used on French destroyers, the battlecruiser guns were expressly dual-purpose and featured a sliding block breech mechanism found in German guns. As a result, these guns used cartridges or fixed-charge ammunition. The high-angle fire requirement, however, resulted in a very elaborate loading mechanism which proved to be failure prone in service.

The secondary turrets were equipped with two different hoist systems to enable an instantaneous shift from shells used in antiaircraft defense to those intended for surface actions. Since the two twin turrets were situated some 30 meters from their magazines, it was necessary to use an ammunition hoist system which featured horizontal and vertical movement. This was accomplished by the use of a chain drive within a tubular hoist. Separate hoists for two shell types was also employed, and there was a break in the ammunition hoist system at the turntable. The after group of three quadruple turrets was positioned over their magazines.

Antiaircraft battery. For air defense, eight 37-mm (CAIL) guns in four twin mounts and thirty-two 13.2-mm Hotchkiss machine guns in eight quadruple mounts were specified. In 1931 such an armament was considered to be excellent for the air defense then required. Neither the *Dunkerque* nor the *Strasbourg* used their antiaircraft batteries in a rigorous defense during the war; therefore, it is difficult to measure their performance. In comparison to other warships, however, they were insufficient in quantity and caliber. In the *French Navy in World War II*, Rear Admiral Auphan and Jacques Mordal wrote:

* The French naval constructors termed these gun positions as turrets.

The main weakness in the Navy's antiaircraft defense—other than the lack of radar—was an insufficiency of machine guns and light guns of 25 mm or 40 mm, for use against low-flying planes and divebombers. The need of such weapons would be bitterly felt in the Norwegian expedition and later off the northern coast of France. One difficulty was that the Navy was dependent on the Army, which was charged with furnishing her with light automatic guns. And the complete lack of divebombing and low-flying attack planes in the French Air Force was not conducive to impressing the Army with the critical need for an adequate number of short-range antiaircraft weapons.

The semiautomatic 37-mm guns, Mark 33, could fire eighty-five rounds per minute. The projectile weighed 0.73 kilograms and had a muzzle velocity of 810 meters per second. The guns could be elevated to 80 degrees and depressed to 10 degrees. Experimental work on these guns resulted in a vastly improved Mark 35 model shortly before World War II, which fired from 166 to 172 rounds per minute. The Mark 35 gun was proposed to replace the Mark 33, but with the threat of war and finally its commencement in September 1939, the French Navy preferred not to lay up its only modern capital ships for alterations, so the conversion was never carried out.

The 13.2-mm guns had a maximum range of 7,196 meters and a ceiling of 4,200 meters. They were intended to provide close-range antiaircraft defense, but despite a rate of fire of 700 rounds per minute, they were totally incapable of defense against either torpedo-bomber or high-level bomber attacks.

Aircraft. The *Dunkerque* and *Strasbourg* were the first capital ships in the world whose original design and construction provided for aircraft. Both ships could carry three Loire-Nieuport 130 floatplanes—one on the catapult and two in a two-deck hangar. One catapult and crane were also provided for the launching and recovery of the aircraft. Since these ships preceded radar, or French aircraft carriers*, their need for air reconnaissance and for spotting fall of shot was mandatory. Unfortunately, the large hangar seriously reduced the field of fire for the after 130-mm lateral quadruple turrets.

Protection. French naval constructors desired the best possible protection, and the protective systems were effective for vessels of such size; they represented 34.59 percent of the trial displacement of 32,500 tons. In the design of the *Dunkerque*, the immunity zone was predicated on withstanding 280-mm shellfire at ranges between 16,600 and 28,300 meters. The French Navy had conducted extensive studies into the problem of armor protection and the development of an effective torpedo-defense system. That they succeeded is attributable to an exhaustive research program and a thorough scale-model test.

These ships used a modified "turtle deck" system of armor protection with an internal and inclined armor belt bounded by two armor decks. This arrangement was termed "caisson blindé"—a long-time favorite of French naval constructors. The subject of side-armor thickness and arrangement was thoroughly investigated during the design evolution. The merits of a vertical and sloping main side belt were debated, and it was finally decided that the side belt would be 225-mm Class A armor inclined

*The *Bearn* was the only operational aircraft carrier. It had been converted from a *Normandie*-class battleship and could carry only a limited number of aircraft. This statement refers only to aircraft carriers built expressly as such—the *Painlevé* and *Foch*.

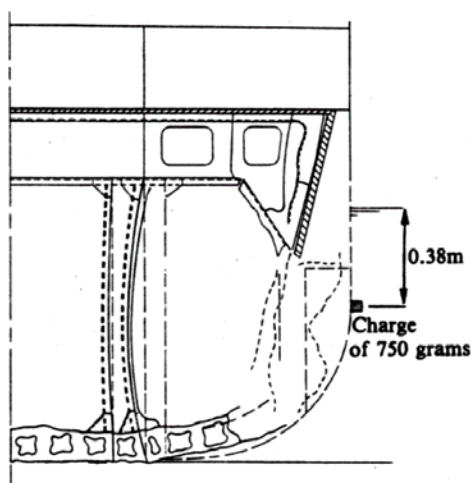


Figure 2-3. One-tenth scale model caisson test.

at 11.3 degrees. The *Dunkerque* was so equipped, but since the *Strasbourg* was authorized three years later than her sister battlecruiser, thought turned to improving her protection. Her side-belt thickness was increased to 283 mm, with the belt inclination remaining the same. The armor protection for the main battery turrets, barbettes, and the forward and after armor bulkheads of the armored citadel were also increased. These changes to the armor protection reduced the imbalance between the armor protection and the main battery caliber.

The side armor belt was reinforced by sloping the lower armor deck outboard. The armor belt had a plate width of 5.75 meters and was inclined at 11.3 degrees from the vertical. The Service Technique Constructions had preferred 225-mm armor plate on 16-mm STS (Special Treatment Steel), inclined at 20 degrees and projected 2.25 meters below the design waterline. The Conseil Supérieur, however, preferred a heavier belt at a greater slope. It would have been difficult to accommodate a larger sloping armor belt adequately in the hull and provide the necessary connections between it and the lower armor deck. Thus, the smaller slope and 225-mm belt armor were chosen. The inclination gave the belt the resistance of a 283-mm vertical plate in the *Dunkerque*, and the increase to 283-mm plate on 16-mm STS at the same slope in the *Strasbourg* produced the effect of a 340-mm vertical plate. The armor belt began to taper about 2.1 meters below the design waterline to 141 mm at its termination on the slope. Thinning the armor in the side belt below the waterline involved no serious dangers, because a shell would lose part of its energy when it hit the water, and the penetration of the ship structure would be correspondingly reduced.

Although it left the side plating unprotected, the sloping armor system was chosen to increase the probability of shells or splinters ricocheting and to give a more effective side-armor system while conserving weight. As the side would be exposed to fragmentation damage, it was decided to use a water-exclusion material in compartments outboard of the main armor belt to prevent lists due to flooding through tears in the side shell.

The side armor was designed to resist the penetration of a 280-mm shell fired at a muzzle velocity of 855 meters per second from a range of 16,600 meters with a target angle of 90 degrees. In the *Strasbourg*, the side armor could resist the same shell fired at a range of 12,900 meters or a 380-mm shell from a French 380-mm/45-caliber (Mark 1935) gun at a range of 24,500 meters. The designers believed that the side-armor belt inclination increased the chances of ricochet and fragmentation. Therefore, the belts would have better resistance than the previously mentioned figures would indicate.

Deck armor. Horizontal protection was determined by two factors: defense against aircraft and adequate protection against the German 280-mm gun. There were two armor decks, the upper deck having the greater thickness (see Table 2-7). The main armor deck consisted of two plates, with the upper plate of 125 mm or 115 mm being Class B armor, and the lower plate being structural and of a special treatment steel (STS). Outboard over the torpedo-protection system, this deck sloped down 54 degrees from the horizontal to its termination at the lower edge of the main side belt. The armored slopes were 50-mm thick. The weather deck was not armored, but was the main structural deck. The horizontal protection was designed to make a projectile explode at the level of the main armored deck, while the deck below was to exclude fragments. French naval constructors were convinced that bombs of that period had little armor-piercing ability and that their explosions could be easily dissipated when thicker armor was employed. The slopes had to have sufficient thickness to reinforce the side-armor belt. The lower armor deck was 1.1 meters above the design waterline. As it would not prevent splinters of projectiles hitting below that level from entering the underwater body, the lower armor deck was sloped outboard to a distance of 2.25 meters below the design waterline.

TABLE 2-7

Deck Armor Thicknesses

	<i>Magazines</i>	<i>Machinery</i>
Main deck	4.92" (125 mm)	4.42" (115 mm)
(STS)	0.59" (15 mm)	0.59" (15 mm)
Second deck	1.57" (40 mm)	1.57" (40 mm)
	7.08" (180 mm)	6.58" (170 mm)

The upper deck was designed to resist a 500-kilogram bomb dropped from an altitude of 3,000 meters, or a 280-mm shell fired from a range of up to 28,300 meters. The armor deck in the region of the main magazines could resist a 380-mm shell fired from a range of 25,700 meters. There was no armor protection beyond the forward armored bulkhead, but some protection was provided aft of the citadel over the steering-gear room and was 100-mm thick on the horizontal and sloped portions over the shafts. The addition of 50-mm special treatment steel to the horizontal armor protection over the steering-gear room in the *Dunkerque* increased the total plate thickness to 150 mm. In the *Strasbourg*, a single thickness of 150-mm armor was used. This arrangement and the sloping of the armor outboard was largely a weight-saving expedient so that heavy belt armor would not have to be used in this section of the ship, and in a sense, duplicate what armor slopes could accomplish.

Conning tower. French naval constructors were convinced that ship-control personnel and equipment should have good armor protection. This armor was underlayed by two courses of 15-mm STS. In both ships, the conning towers were two decks high, with similar armor thicknesses but slightly different configurations. A special lookout position in the upper conning tower was also provided with armor protection.

Armored bulkheads. The *Dunkerque* and *Strasbourg* had three major transverse armored bulkheads and several other major transverse watertight bulkheads fitted with special treatment steel for splinter protection. The thicknesses for the transverse bulkheads were determined by an extensive analysis of striking angles of a 280-mm shell. There were differences in armor thicknesses between the two ships, as in the main side belt and barbettes. In the *Dunkerque*, the forward armored bulkhead was

fitted with 210-mm face-hardened (cemented) armor on 18-mm STS, thinning to cemented 130-mm armor on the same thickness STS outboard of the torpedo bulkhead to shield the main-battery magazines. Thinning the outboard segment was done to save armor weight, since a shell striking this portion of the ship would have to penetrate the main side belt to gain entrance to the main-battery magazines. The heavier centerline segment provided protection against fire from ahead. In the *Strasbourg*, the cemented armor was increased to 260 mm on the centerline segment. The two-course armor-plate construction extended from the upper armor deck to the top of the triple bottom in way of the forward magazines. The armor for the after bulkhead was arranged differently because of the extension of the lower armor deck aft to protect the steering gear and the need to provide protection for the secondary battery magazines. The portion between the upper and lower armor decks was 180-mm class A armor in the *Dunkerque* (210 mm in the *Strasbourg*) on 18-mm STS, decreasing to 80-mm class A armor below the lower armor deck in both ships. The reduced thickness of armor was possible because the lower armor deck would have acted in conjunction with the bulkhead armor to exclude shells from the 130-mm magazines aft. The after bulkhead in the steering-gear room in the *Dunkerque* carried 100-mm class A armor on 50-mm STS, while in the *Strasbourg* this bulkhead was a single thickness of 150-mm class A armor plate. The forward bulkhead of this space had only 50-mm armor, because it was shielded by thicker armor on the sides and deck. Several main transverse bulkheads were constructed of 18-mm STS for local splinter protection. Bulkheads bounding the diesel generator room, located between the two 330-mm magazines, the after bulkhead of the after main-battery magazine, the after bulkhead of the forward engine room, the forward bulkhead of the 130-mm magazines, and a bulkhead between the after armored bulkhead and the steering-gear room had this type of protection.

Turret armor. The main-battery turrets were well protected in the *Dunkerque*. In the *Strasbourg* further emphasis on armor protection yielded thicker face plates (increased from 330 to 360 mm) and consequently the blackwalls of both turrets had to be increased to maintain turret balance. The turret-roof protection (150 mm in *Dunkerque*, 160 mm in *Strasbourg*) was greater than the deck armor over the magazines. Nonetheless, the *Strasbourg* still featured heavier turret protection. The turret platform protection varied according to location and exposure; again, there was more protection in the *Strasbourg*. No additional armor was provided within the gun house except that an armored bulkhead on the centerline divided it into two separate gun chambers. Turret armor thicknesses were based on a thorough analysis of bomb and shell hits at varying impact angles.

The main turret barbettes, containing a large amount of machinery and the ammunition supply for each half turret, had a uniform armor thickness of 310 mm. Two courses of 15-mm STS were used to back up this armor protection. The continuation of barrette armor protection between the upper and lower armor deck decreased to 50-mm STS plate. The critical ranges for the barbettes in the *Dunkerque* are tabulated in Table 2-8.

The secondary armament had only limited protection because of weight and stability considerations. The weight saved by omitting thick armor for the secondary turrets permitted added protection on the side-armor belt and main turrets. The quadruple turrets were designed to resist medium-caliber shells, while the twin mounts were protected only against bomb or shell fragments. The quadruple secondary turrets had 135-mm face plates, 90-mm sides, 80-mm backwalls, 90-mm roofs, and platforms varying from 30 mm to 90 mm according to location. The quadruple secondary turrets were mounted within a 120-mm barrette. The two twin turrets had only 20-mm STS

TABLE 2-8

Penetration Ranges for Barbettes

<i>Shell</i>	<i>Muzzle Velocity</i>	<i>Penetration Range</i>
8" (203 mm)	2,789 fps (850 mps)	6,450 yards (5,900 m)
11" (280 mm)	2,805 fps (855 mps)	16,050 yards (14,680 m)
13" (330 mm)	2,805 fps (855 mps)	23,600 yards (21,550 m)
14" (356 mm)	2,756 fps (840 mps)	27,700 yards (25,300 m)

protection on their sides, roof, and face plates, since their magazines were located some 20 meters forward of the turrets.

Because of the limited standard displacement, splinter protection was minimal. The intakes to and the uptakes from the boilers were provided with a 20-mm armored enclosure with no access through the sides. This protection was carried one deck above the main armor deck and, within the splinter-box enclosure, special armor gratings were used for all penetrations in the armor deck itself. Between the two armor decks, 20-mm STS was used for the main longitudinal bulkheads and for some transverse bulkheads. The forward superstructure periphery was provided with 10-mm special treatment steel for the blast effects of the 330-mm guns.

Side protection system. Much emphasis was given to underwater protection, as the French Navy was convinced that the torpedo was the greatest single threat to a capital ship. Considerable research was accomplished before a series of model tests on a representative capital-ship section established the effects of a 300-kilogram charge of TNT in contact with the side plating. From the test on a representative one-tenth scale model of these battlecruisers (figure 2-3), it seemed reasonable to expect that underwater protection could be effective against such a charge. The test confirmed that a series of longitudinal compartments, divided by properly spaced transverse bulkheads, was mandatory, and the total breadth of the underwater protective layer amidships should be at least 7 meters at a distance of 3.5 meters below the design waterline. It was further concluded that the large outboard compartment, where the explosive gases would expend much of their energy, should be filled with a tenacious gum-like substance called "ebonite mousse." This material had a specific gravity of approximately 0.07 to 0.10, would not absorb seawater even under high pressure, and was capable of absorbing some of the explosion's energy. French naval constructors were also hopeful that it would reduce the hazards resulting from splinters and unsymmetrical flooding. Underwater explosion tests during 1934 at Lorient with a test caisson of four-tenth scale confirmed all the calculations and previous results derived from the one-tenth scale model.

Due to the decreased width in the torpedo defense system because of the taper in the hull at the ends of the armored citadel, the torpedo bulkhead was increased in thickness towards these ends and, in way of the three forwardmost main compartments in the citadel, water-exclusion material was added to the space outboard of the torpedo bulkhead.

The major dimensions of the torpedo defense system are tabulated in Table 2-9. The side protection system was divided into four compartments by three longitudinal bulkheads (see Midship Section). The number of bulkheads diminished to two over the last main watertight compartment in the armored citadel, hence the need to increase the torpedo bulkhead thickness. The breadth of the system decreased towards the ends of the armored citadel because of the fine hull form required for speed. In the propulsion plant, an additional compartment, 1.2 meters deep and inboard of the torpedo bulkhead, served as a wireway and pipe tunnel. No connections were made to the torpedo bulkheads for pipe and cable hangers.

TABLE 2-9

Characteristics of the Side Protection System

<i>Location</i>	<i>Depth at 11.48' (3.5 m) below design waterline</i>	<i>Total Bulkhead Thickness</i>	<i>Torpedo Bulkhead Thickness</i>
Turret I	12.30' (3.75 m)	3.31" (84 mm)	1.97" (50 mm)
Turret II	18.24' (5.56 m)	2.91" (74 mm)	1.57" (40 mm)
Amidships	22.97' (7.00 m)	2.52" (64 mm)	1.18" (30 mm)

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The bulkhead which formed the inboard boundary of the outermost wing tank was a major structural component of the hull girder. The transverse-spaced side frames and a number of closely spaced longitudinals formed a grillage so that the side shell plating ranged from 9-12 mm in the vicinity of the side protection system. Void, oil-filled, and void spaces were arranged between the outer compartment and torpedo bulkhead. The space filled with oil had a maximum breadth of almost 5 meters. The torpedo bulkhead varied in thickness and was brought inboard in proximity to the main and after group of secondary turrets without any discontinuities. This provided as much breadth in the torpedo defense system as possible in an area where the hull form tapered. The torpedo bulkhead was 50-mm STS in the area of the after 130-mm turrets and the forward 330-mm magazine, where the hull form reduced the breadth of the torpedo defense system the most. It decreased to 40 mm over the compartments immediately adjacent and then to 30 mm for the remaining portion of the armored citadel. It was not possible to provide any deeper protection at 3.5 meters below the design waterline without changing the beam.

The underwater protection system was designed to absorb explosive energy by the plastic and elastic deformation of structure and the hydraulic resistances of the fuel oil. The shell plating and the supporting structure were expected to explode the torpedo. The ebonite mousse in the outboard compartments the length of the armored citadel and in the compartment just outboard of the torpedo bulkhead near the main and secondary quadruple turrets provided additional material for further absorption of energy. The transverse extent of this layer at half draft was about 1.5 meters. Inboard of this area the liquid-void system began.

The *Dunkerque*-class battlecruisers had localized underbottom protection for the main and secondary magazines. Armor plate of 30-mm thickness formed the inboard boundary of the triple bottom under the turrets; elsewhere in the armored citadel, there was a simple double bottom some 1.1 meters deep. This was rather shallow but necessary to accommodate the propulsion plant. The need for the underbottom protection against mines was recognized, but in this displacement-limited design it was possible to protect only the main battery magazines. In order to prevent the total loss of compartments through flooding or splinter damage, several major transverse bulkheads within the armored citadel were constructed of 18-mm armor plate.

Stability and subdivision. These ships had good stability characteristics for their size; they were designed to withstand the flooding of any two major watertight compartments and had a range of stability of 64.33 degrees at their design waterline. The reserve buoyancy totaled some 28,160 metric tons, and the metacentric height (GM) was 2.62 meters at the normal displacement of 30,750 tons.

Radar. Radar development in France began in 1933, and between 1934 and 1939 a number of experiments were carried out. In 1935 the French Navy became interested

in shipboard radar after analyzing the results of a radar demonstration. Tests were made in the plant of the Société Française de Radio Électrique, and later navigational radar sets were installed in the fishing sloop *Ville Dy's* for the detection of icebergs, in a cargo ship, and finally in the SS *Normandie*. These sets were highly successful and raised the possibility of using radar to detect aircraft. By 1939, air warning radars using metric waves were in operation around Cherbourg, Brest, Toulon, and Bizerta.

The development of French radar was under strict secrecy until 1938, when a mutual exchange of information began with the British. All research was centered upon metric waves and long-range aircraft detection. The first set tested in September 1939 had an output of 14kw and a range of 50 to 60 kilometers. Continued work increased the power and range, but a new problem developed when German aircraft began to drop mines. It was necessary to detect such planes at a range of 30 kilometers and an altitude of only 50 meters, which required the development of shorter wave equipment. By January 1940 such a set was in working order. Because of the German breakout at Sedan in May 1940, experiments were halted and material destroyed, but not before a 16-cm magnetron tube was given to the British for their use in the development of a centimeter-wave radar set. British and French cooperation on radar development ceased with the signing of the Armistice in June 1940.

All work up to 1941 centered on land-based air-detection radar, but late in 1940 work commenced on shipboard installations. Air-warning radar installed in the *Strasbourg* in 1941 could detect aircraft at altitudes of 1,500 meters and ranges of 80 kilometers, 1,000 meters at 50 kilometers, and a few meters above the surface at 10 kilometers.

The problem of an all-around sweeping aerial was solved on board the *Strasbourg* by the installation of four synchronized aerials fitted on the yardarms of the forward bridge tower at angles of 45 degrees from the ship's centerline. The starboard forward and port-side aft aerials were transmitters; the remaining two were receivers. Trials took place in June and July 1942 at Toulon, but performance could not be ascertained because of poor conditions. Research ceased in November 1942 when the Germans occupied Southern France. Much equipment had to be destroyed.

Propulsion Plant. Great emphasis was placed on speed, since these ships were to make use of superior firepower and speed in any engagement with German ships of the *Deutschland* class. From the inception of the *Dunkerque's* design, speed was required to be at least 29.5 knots at the normal displacement of 31,500 metric tons with fuel tanks filled to half-maximum capacity. Shaft horsepower necessary for that speed was estimated to be 105,000 metric horsepower; it was exceeded during the trials for both ships. Shaft horsepower at the nominal rate, 112,500, was good for 30 knots. Maximum power at overload was 135,585 metric horsepower.

Boilers and turbines. The propulsion plant used moderately high-pressure, high-temperature boilers with Parsons-type turbines and single reduction gears. The six boilers of the classic Indret type ("flamme directe") had three lower collectors (drums), a central network of tubes, with two burners and a combustion air preheater. The designed operating pressure was 27 kilograms per square centimeter at 350 degrees centigrade. The turbines, built by Électro-Mécaniques, were quite efficient, although coupled to single reduction gears.

The unusual machinery arrangement differed markedly from that of previous battleship designs. With fewer boilers and an effective torpedo protection system, it was

considered acceptable to concentrate the propulsion plant in five watertight compartments, with two boilers in each of the three firerooms and two turbine sets in each of the two engine rooms. Longitudinal bulkheads were avoided in these ships to prevent offcenter flooding of major engineering spaces. The machinery plant was very compact due to the hull length and the displacement limitations. The concentration involved the risk of losing all power on two shafts as the result of one mine detonation or torpedo hit. The rather bold concentrated arrangement resulted from the confidence that the torpedo defense system would provide the necessary protection from torpedo hits, about which the French naval constructors were very concerned. The turbines for the outer shafts were in the forward engine room, those for the inboard shafts were in the after engine room. Cross connections permitted the boilers for either engine room to power the turbines in the other.

The designed endurance for the *Dunkerque* was 15,000 miles at a cruising speed of 15 knots. This was a design requirement. The *Dunkerque*'s nominal fuel capacity was 5,775 metric tons, which yielded an endurance of 3,730 miles at 31 knots and 16,416 miles at a speed of approximately 17 knots. Endurance figures for the speeds indicated would have been slightly less in service. Highly successful preliminary sea trials were conducted by the Brest Navy Yard in May 1936. A 24-hour trial was run at an average of 52,883 metric horsepower and a speed of 25.3 knots. Pertinent trial data is summarized in Table 2-10. These trials were run with a clean bottom, in a smooth sea, and with a favorable wind.

TABLE 2-10

Preliminary Trials Data—Dunkerque

	<i>Cruising</i>	<i>Normal Maximum</i>	<i>Overload</i>
Duration	—	8 hours	2 hours
Speed	18.12 knots	30.37 knots	31.06 knots
Power			
SHP	15,475	112,490	133,730
(MHP)	(15,690)	(114,050)	(135,585)
Fuel Consumption			
lb/mile	767	2,789	3,413
kg/mile	348	1,265	1,548

In France, after official trials are conducted, the boilers and propelling machinery are taken apart for inspection while the ship is in drydock. Later, acceptance trials were run on the Penmar'ch-Guilvinec run (off Brittany), producing the results tabulated in Table 2-11. These trial figures indicate that the *Dunkerque*-class battlecruisers had excellent endurance characteristics for their size. Based upon the 5,775-ton fuel capacity in the *Dunkerque*, the endurances at the speed indicated have been summarized in Table 2-12. As the armor was heavier in the *Strasbourg*, it was necessary to increase the fuel capacity to maintain the same endurance as the *Dunkerque*.

TABLE 2-11

Acceptance Trials Data—Dunkerque

Duration	3 hours	3 hours	3 hours	2 hours	3 hours
Speed	17.31 knots	20.68 knots	25.24 knots	28.30 knots	30.38 knots
Power					
SHP	12,931	24,845	52,127	80,425	111,869
MHP	13,110	25,190	52,850	81,540	113,420
Fuel consumption					
lb/mi	776	1,058	1,632	2,205	3,004
kg/mi	352	480	740	1,000	1,362

TABLE 2-12

Endurance Characteristics—Dunkerque

<i>Speed</i>	<i>Endurance</i>
17.31 knots	16,416 nautical miles
20.68 knots	12,039 nautical miles
25.24 knots	7,800 nautical miles
28.30 knots	5,775 nautical miles
30.38 knots	4,241 nautical miles

Thus, fuel-oil capacity in the *Strasbourg* rose to 6,045 tons. High speeds at low horse-powers in the tabulations in Table 2-12 were achieved with a fine hull form (block coefficient = 0.54). These ships also had a modest bulbous bow and a cruiser stern with a single centerline rudder.

Electric plant. French naval constructors recognized that the extensive use of electric power in these battlecruisers could save considerable weight and space. It was also recognized that equipment for such areas as the commissary and refrigeration spaces could be procured from manufacturers specializing in such equipment in shoreside facilities. It was also decided to equip the main and secondary guns with electric drive. However, the electric motors for the training and elevating gear of the 330-mm turrets would require a much larger voltage than the normal ship current could provide. It was decided to design the electric plant so that two currents could be produced—230 and 460 volts. Three electric plants were provided. Two turbogenerators with two 450kw generators per unit were installed in each engine room. A total of 1800kw could be generated by each station in each of the engine rooms. The third electric generating plant was for emergencies and consisted of three diesels driving a 400kw generator on each shaft. Thus, a total of 1200kw was available for 230- or 460-volt current in case the turbogenerators could not be operated. The diesel generators could, for a short period of time, produce 480kw. Two smaller 100kw emergency diesel generators were located on the forecastle deck (Pont Supérieur) and could supply 230-volt current only. A total of 5,000kw could be generated by a *Dunkerque*-class battlecruiser. The electrical system was primarily direct current, but some alternating current was available for equipment requiring it. The basic shipboard electric power was 230 volts DC, but the generator arrangement permitted the production of 460 volts for use in the 330-mm turret power supply.

The electric plant was divided into four stations, one for the emergency power. Each station was autonomous and could handle the normal 230-volt current or the special 460-voltage for the 330-mm turrets. The three stations in the diesel generator compartment between the main-battery turrets and the two engine rooms could produce the normal shipboard current, but could not simultaneously provide the larger 460-volt current, since the generation of this latter current required a special hook-up of the generators in series. While either ship was in combat, two electrical stations would be in operation to supply the two different voltages, while a third was in standby.

The dependence of these battlecruisers on electrical power necessitated some duplication of their electrical circuits in case of battle damage to cabling. Port and starboard wire and pipe tunnels extended from the after 330-mm magazine to the after 130-mm magazine. The cabling for each deck was independent of that of the decks above and below, as well as that of the opposite side. All cabling penetrations in the bulkheads were watertight. A third wire tunnel in the double bottom provided a third circuit in case both wing wire and pipe tunnels were damaged. A separate circuit was also provided for those areas above the upper armor deck.

Hull Characteristics.

Welding. In order to save weight and improve the structure, more electrical welding was used than in any previous French warship. Longitudinal framing, the torpedo bulkhead plating, transverse bulkheads, and much of the secondary structure were welded, using stainless steel electrodes.

Framing. The framing system, as in many of the battleships of that period, was a mixture of transverse and longitudinal members. Transverse framing was limited to the armor decks; the side shell was a combination of both systems. All other framing, including the strength (main) deck and inner bottom, was longitudinal, primarily to save weight. At the turn of the bilge small longitudinals were fitted between the main transverses to strengthen the outer plating against explosive loads. This construction, typical of later French battleships, was derived from explosive tests on model-test sections of the *Dunkerque*.

Summary. The *Dunkerque* and *Strasbourg* demonstrated some new concepts in their design that would be reproduced in the *Richelieu*-class battleship design which was to follow. Both ships were responses to German armored ship construction. The *Dunkerque* was a true battlecruiser as characterized by her high speed, 330-mm guns, good endurance, and the lack of really thick armor protection. This was keenly revealed at Mers el Kébir, where she sustained severe shell damage. Major damage to this ship from 381-mm projectiles resulted from inadequate armor protection of her vitals against projectiles of more than 280-mm caliber. The *Strasbourg* could be considered a small-displacement battleship, since she had thicker protection on her sides, armored bulkheads, and turrets, but the deck protection, being the same as the *Dunkerque*, was relatively weak for capital ships of the World War II era.

The standard displacement limited to 26,500 tons by the Washington Treaty was a great design disadvantage. Whenever displacement is arbitrarily restricted, it complicates design and necessitates compromises of important features such as armor or ordnance. The design requirements called for high speed, long endurance, good underwater protection, and relatively heavy fire power. The armor protection was designed to counter only German 280-mm shells. This compromise resulted in a ship susceptible to serious damage by most battleships. Table 2-13 compares the main gun power and protection of the *Strasbourg* and the old battleship *Bretagne* built before World War I. The comparison is very striking, considering that the belt armor of the *Bretagne* was vertical and 273-mm thick, compared to the 283-mm sloping belt in the *Strasbourg*.

It can be inferred from the table that the fire power was reduced to accent the protection in the *Strasbourg*. This is not entirely true, because the *Bretagne* had five twin tur-

TABLE 2-13

Comparison of *Strasbourg* and *Bretagne*

	Displacement Standard—Metric Tons	Main Armament	Gun power*	Protection*
<i>Strasbourg</i>	28,600	Eight 13" (330-mm)	13.89%	41.63%
<i>Bretagne</i>	22,600	Ten 13.4" (340-mm)	18.37%	33.98%

* Percent of standard displacement.

rets with older 340-mm guns, while the *Dunkerque*-class battlecruisers had two quadruple turrets with much more powerful 330-mm guns. More emphasis was placed on protection in the *Dunkerque* and *Strasbourg*, however, as the result of advancements in gun technology and aircraft bombing techniques. This can be observed in the horizontal armor protection, where the *Bretagne* had a total armor thickness of 89 mm compared to the deck-armor thickness of 155 mm to 165 mm in the *Dunkerque* and *Strasbourg*. The largest increase was in the deck-armor protection, which was the principle contributor to the increase in the percentage. In the *Dunkerque* the percentage of armor to the standard displacement was slightly less—approximately 40 percent. Increased deck protection was gained in this battlecruiser at the cost of reduced side-armor thickness, a measure which the Service Technique Constructions questioned. In the *Strasbourg* this imbalance was removed. The trend towards the emphasis on protection was clearly shown in the *Dunkerque* and *Strasbourg*, and this would be true in all modern battleships that were built thereafter.

The underwater protection was one of the deepest systems adopted in a modern capital-ship design. The explosion of forty-two depth charges near the *Dunkerque* proved the toughness of the system, although a major portion of the explosive force was vented to the water surface and away from the ship. The torpedo-defense system was one of the best known and was used in the *Richelieu*-class battleships with some minor modifications.

The forward concentration of the main battery was a rather bold, but understandable, measure in the design of these ships. Emphasis was on weight saving. With the main guns concentrated forward, only one gun director was required; it was located forward of the stack on the command tower to minimize stack-gas interference. Placing the guns forward also permitted the boat and aircraft stowage to be well separated from their blast effects. The one disadvantage of the arrangement was that it left a stern sector of some 60 degrees unprotected by main-battery fire. The mission of the ships and the need for weight conservation were the deciding factors, however. At Mers el Kébir in the only serious test of the arrangement, the *Dunkerque*'s gun performance was poor due to her being bow on to the beach and having a limited field of fire.

The secondary armament, a dual-purpose type, was technically advanced in conception. When the design of the *Dunkerque* began, French naval strategists were convinced that aircraft would be an important factor in future naval warfare, and they were willing to sacrifice some main-battery guns for good antiaircraft protection. Nevertheless, close antiaircraft protection was extremely weak against World War II aircraft and became a source of concern. If these ships had survived the war, they probably would have had an entirely new light antiaircraft battery to supplement the sixteen 130-mm guns, as did the rebuilt *Richelieu* and *Jean Bart*.

The propulsion plant was very compact, but concentration into only five major spaces made it possible for a single hit to disable two propeller shafts. This was a bold decision, forced on designers because of the limited volume available and the need for weight conservation. The torpedo protection system, however, was sufficiently broad at this point to diminish this possibility.

The *Dunkerque* and *Strasbourg* had many novel and advanced design features and were remarkably powerful and well protected for their limited displacement. In particular, the side protection system, good horizontal protection, and the dual-purpose secondary battery were successful concepts. Their high speed and considerable endurance were, unfortunately, attained at the price of a modest main-battery armament and reduced side-armor protection in the case of the *Dunkerque*. The *Dunkerque*-class ships, as battlecruisers, were a successful design, but they were incapable of fighting battleships on an equal basis.

Name	<i>Dunkerque</i>	<i>Strasbourg</i>
Builder	Brest Navy Yard	Chantier de St. Nazaire-Penhoët, St. Nazaire
Laid down	24 December 1931	25 November 1934
Launched	2 October 1935	12 December 1936
Commissioned	1 February 1936	...
Operational	1 May 1936	1939
Disposition	Scuttled in Toulon on 27 November 1942, scrapped in 1958.	Scuttled in Toulon on 27 November 1942, scrapped in Toulon in 1955.

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Displacement

Dunkerque

25,907 tons (26,324 mt) Light ship—1936
 30,907 tons (31,448 mt) Normal displacement (approx. ½ fuel)
 30,264 tons (30,710 mt) Normal—design
 34,884 tons (35,444 mt) Full load—1936

Strasbourg

31,687 tons (32,190 mt) Normal—design (estimated)

Dimensions

Dunkerque

705'10" (215.14 m) Length overall
 685'8" (209.00 m) Waterline length
 102'0" (31.10 m) Beam
 55'7" (16.95 m) Depth at side.
 31'7" (9.63 m) Mean draft at 34,884 tons (35,444 mt)
 28'1" (8.55 m) Design waterline

Strasbourg

707'0" (215.50 m) Length overall
 685'8" (209.00 m) Waterline length
 102'0" (31.10 m) Beam
 55'7" (16.95 m) Depth at side
 28'1" (8.58 m) Mean draft at 30,280 tons (30,766 mt)

Armament

Eight 13"/52-caliber (Mark 1931) (330 mm)
 Twelve 5.1"/45-caliber (Mark 1932) (130 mm)

Antiaircraft machine guns

Ten 1.46" (37 mm) in five twin mounts
 Thirty-two 0.52" (13.2 mm) in eight quadruple mounts

Aircraft

Three Loire-Nieuport 130 seaplanes—one catapult

Hull characteristics at designed draft—*Dunkerque*

Displacement 30,256 tons (30,750 mt)
 Draft 28'1" (8.55 m)

Freeboard

Forward 27'11" (8.50 m)
 Amidships 27'7" (8.40 m)
 Aft 21'8" (6.60 m)

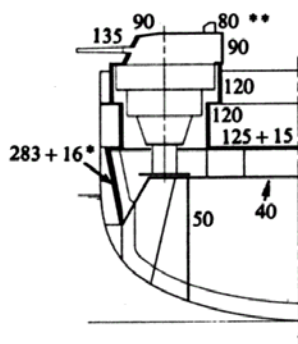
Depth (Amidships) 55'7" (16.95 m)

Block coefficient 0.540

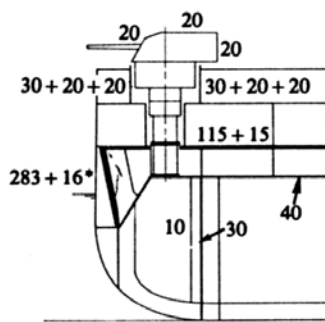
Frames



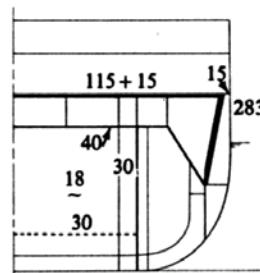
Frame 32
Aircraft hangar



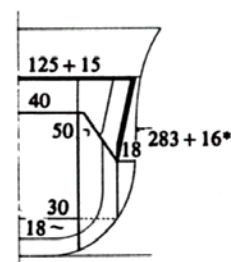
Frame 53.5
Aft Secondary Turrets



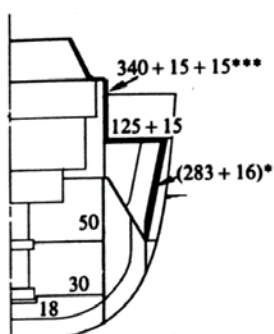
Frame 91.50
Forward secondary turrets



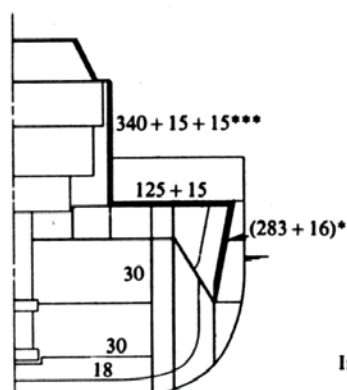
Frame 121.55
Aft turret II magazine



Frame 167.35
Forward Armored
Bulkhead



Frame 156.85
Turret II



Frame 128.05
Turret I

In Strasbourg:
*(225 + 16)
**(90)
*** (310 + 15 + 15)

Armor Protection

Immunity zone

Dunkerque 18,160 yards (16,600 meters) to 31,060 yards (28,400 meters) against a 11.0" (280-mm) shell with a muzzle velocity of 2,805 fps (855 mps)

Strasbourg 14,100 yards (12,900 meters) to 31,060 yards (28,400 meters) against 11.0" (280-mm) shell with a muzzle velocity of 2,805 fps (855 mps)

Amidships and ends

Belt armor

Dunkerque 8.86" + 0.63" (225 + 16 mm) tapered to 4.92" + 0.63" (125 + 16 mm) inclined at 11.3 degrees

Strasbourg 11.14" + 0.63" (283 + 16 mm) inclined at 11.5 degrees.

Deck armor upper armor deck 4.42" + 0.59" (115 + 15 mm)—machinery/130-mm magazines
lower armor deck 1.57" (40 mm)

5.99" + 0.59" (155 mm + 15 mm)

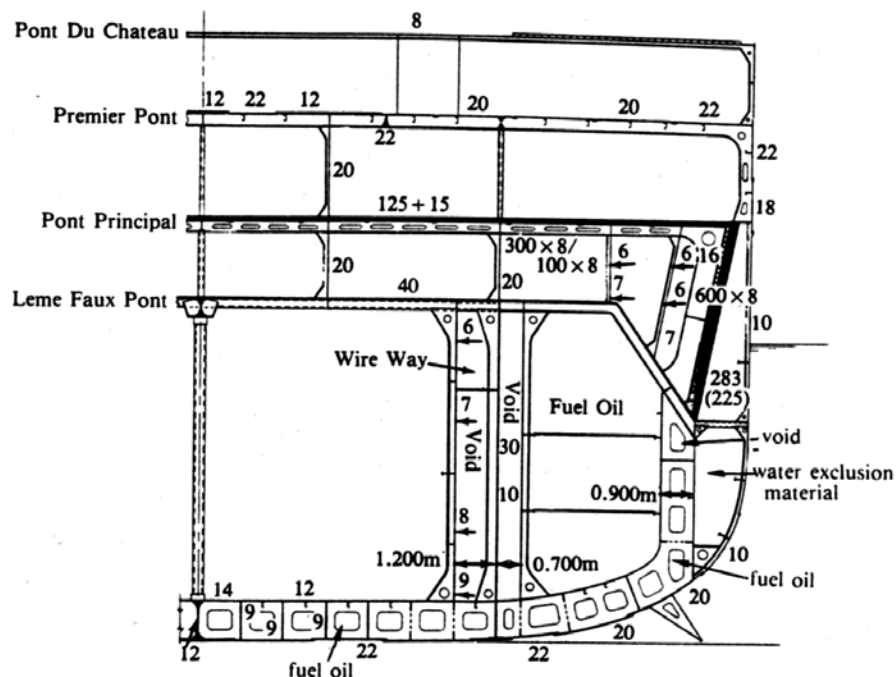
upper armor deck 4.92" + 0.59" (125 + 15 mm)—main magazines
lower armor deck 1.57" (40 mm)

6.49" + 0.59" (165 + 15 mm)

Turret armor

	<i>Dunkerque</i>	<i>Strasbourg</i>
face plates	12.99" (330 mm)	14.17" (360 mm)
sides	9.84" (250 mm)	9.84" (250 mm)
back plates	13.58" (345 mm)	13.98" (355 mm)
Turret I	13.58" (345 mm)	13.98" (355 mm)
Turret II	13.29" (335 mm)	13.98" (355 mm)
roof plates	5.91" (150 mm)	6.30" (160 mm)

Midship Section



Secondary gun protection (*Dunkerque & Strasbourg*)

	Quadruple turrets	Twin Mounts
face plates	5.32" (135 mm)	0.79" (20 mm)
sides	3.54" (90 mm)	0.79" (20 mm)
back plates	3.15" (80 mm)	0.79" (20 mm)
roof plates	3.54" (90 mm)	0.79" (20 mm)
barbettes	4.72" (120 mm)	

Barbette armor (main turrets)

Dunkerque
12.21" + 0.59" + 0.59"
(310 + 15 + 15 mm)

Strasbourg
13.39" + 0.59" + 0.59"
(340 + 15 + 15 mm)

Conning tower armor: (*Dunkerque & Strasbourg*)

centerline forward	10.63" (270 mm)
sides	10.63" (270 mm)
centerline aft	8.66" (220 mm)
roof	5.12" (130 mm)
communications tube	6.30" (160 mm)

Underwater Protection

Designed resistance 660 pounds (300 kgs) of TNT

Depth of side protection 22.97 feet (7.00 m) at 11.48 feet (3.5 m) below design waterline

S.P.S. loading foam-void-fuel oil-void

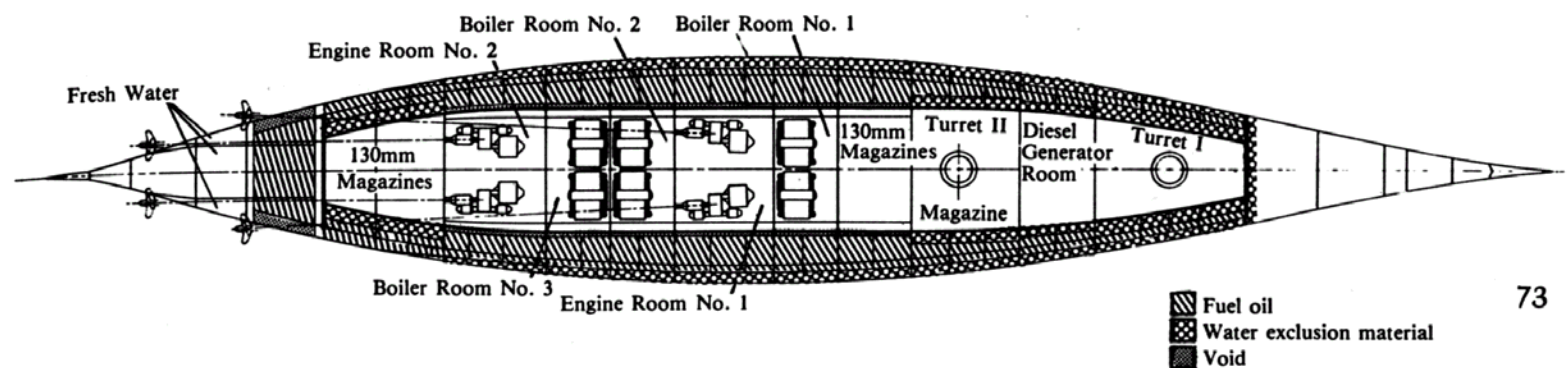
Total bulkhead thickness 2.52" (64 mm) at amidships

Bottom protective system depth 3.60' (1.100 meters)

Tank Capacities

	<i>Dunkerque</i>	<i>Strasbourg</i>
Fuel oil	5,664 tons (5,775 mt)	5,948 tons (6,045 mt)

Machinery Schematic — Hold Plan

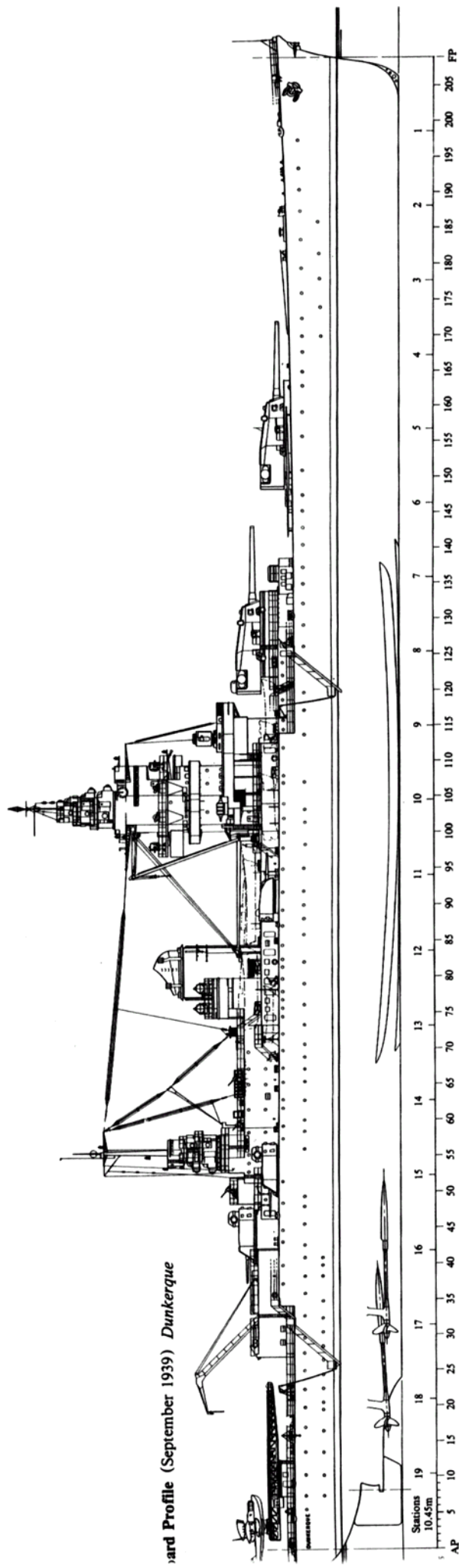


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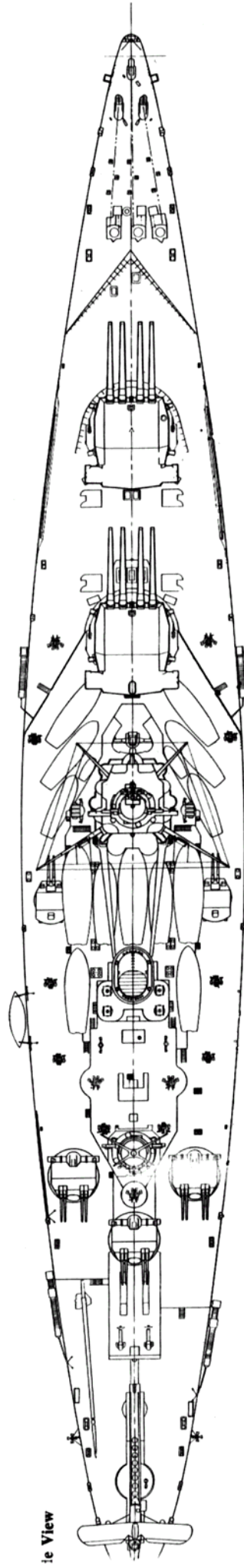
Machinery

Boilers	six Indret vertical small tube "flamme directe" type pressure: 384 psi (27 kgs/cm ²) temperature: 662°F (350°C)
Turbines	four sets of Parsons-type geared turbines by Constructions Électro-Mécanique with single reduction gears.
Shaft horsepower	110,960 (112,000 mhp) normal maximum
Maximum speed and trial data:	
<i>Dunkerque</i>	30.37 knots at 112,490 shp (114,050 mhp) 31.06 knots at 133,730 shp (135,585 mhp)
Nominal Endurance	
<i>Dunkerque</i>	16,400 nautical miles at 17.31 knots 4,200 nautical miles at 30.38 knots
Generators	eight 450-kw generators driven by four steam turbines (two generators per turbine) three 400-kw diesel generators two 100-kw emergency diesel generators 230/460 Volt DC
Propellers	4
Rudders	1
Miscellaneous	
Complement	1,381 (56 officers/1,319 enlisted/6 civilians) <i>Dunkerque</i>

Starboard Profile (September 1939) Dunkerque

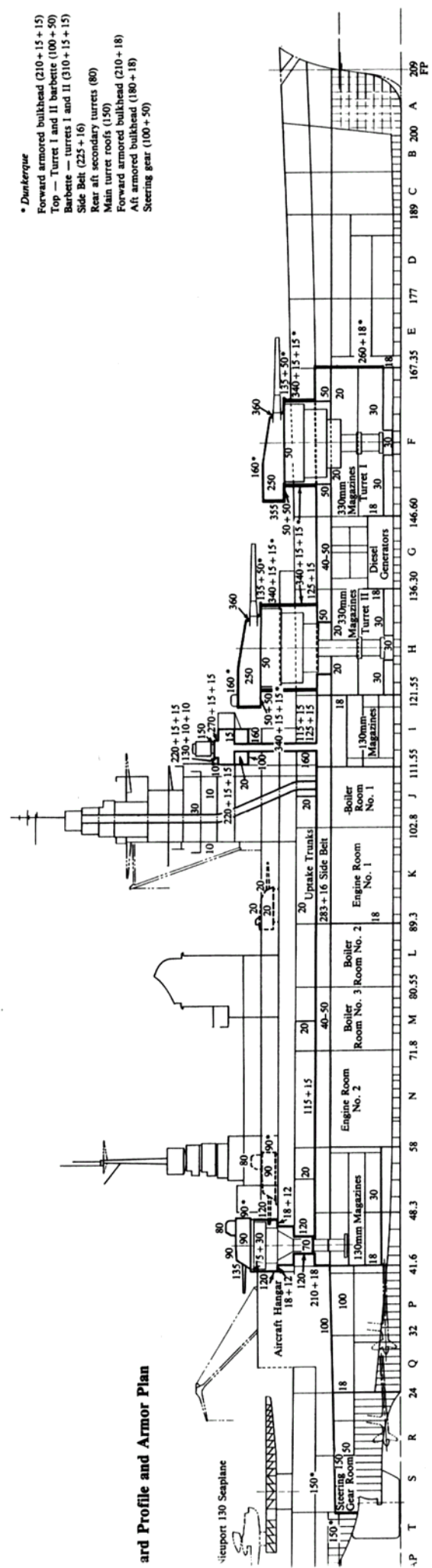


Deck View

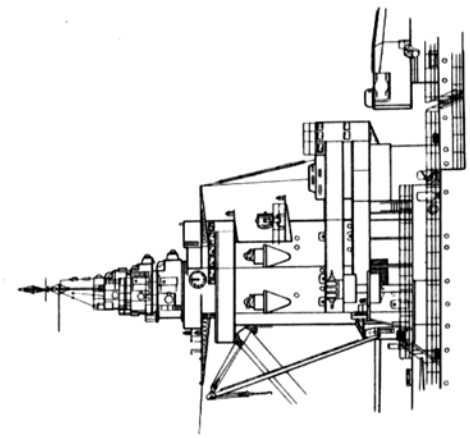


- *Dunkerque*
- Forward armored bulkhead (210 + 15 + 15)
- Top — Turret I and II barbette (100 + 50)
- Barbette — turrets I and II (310 + 15 + 15)
- Side Belt (225 + 16)
- Rear aft secondary turrets (80)
- Main turret roofs (150)
- Forward armored bulkhead (210 + 18)
- Aft armored bulkhead (180 + 18)
- Steering gear (100 + 50)

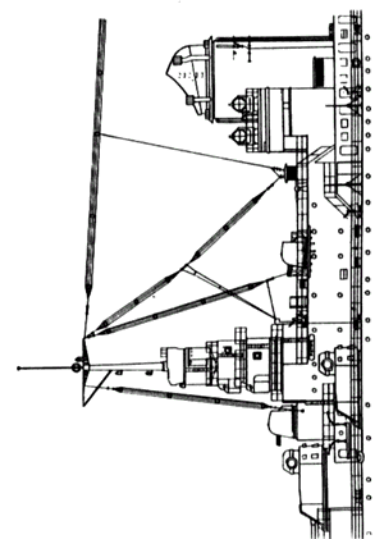
ard Profile and Armor Plan



Frame Spacing and Distance in Meters.



Strasbourg main bridge structure — September 1939

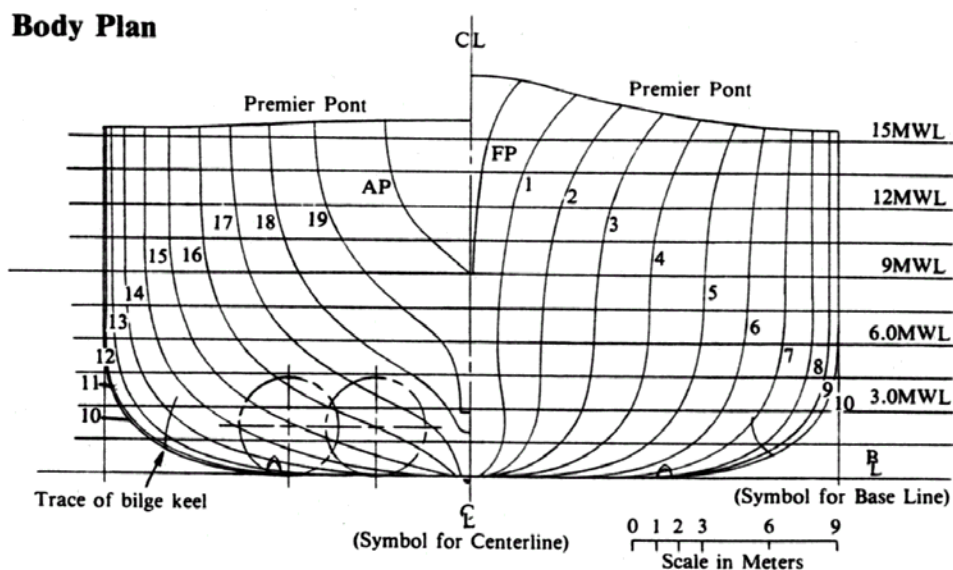


posed 1939 modification — Dunkerque

Weight Summaries

	Tons	Metric tons	Percent of total
<i>Dunkerque</i>			
Hull with all fittings	7,750	(7,874)	29.9%
Outfit	1,850	(1,880)	7.1%
Protection (armor)	11,012	(11,192)	42.5%
Machinery	1,888	(1,918)	7.3%
Armament including aeronautical	3,405	(3,460)	13.1%
Light ship displacement	25,905	(26,324)	100%
Ammunition and stores	1,947	(1,978)	
Fuel oil (½ capacity)	2,841	(2,888)	
Normal displacement	30,693	(31,194)	at a draft of 28.58 (8.71 m)
<i>Strasbourg</i> (authors' estimate)			
Hull with all fittings	7,760	(7,834)	29.1%
Outfit	1,850	(1,880)	7.0%
Protection	11,705	(11,896)	44.0%
Machinery	1,888	(1,918)	7.1%
Armament including aeronautics	3,405	(3,460)	12.8%
Light ship displacement	26,608	(27,038)	100%
Ammunition and stores	1,947	(1,978)	
Fuel oil (½ capacity)	2,974	(3,023)	
Normal displacement	31,529	(32,039)	

Body Plan



Protection (*Strasbourg*)—as completed

Hull	belt	2,900	(2,947)
	armored bulkheads	421	(428)
	splinter protection	120	(122)
	lower armor deck	1,175	(1,194)
	upper armor deck	2,674	(2,717)
	openings (gratings)	143	(146)
	reinforcement of transverse bulkheads	101	(102)
	STS under armor	87	(89)
	torpedo protection	960	(975)
Turrets—main (330 mm)		2,256	(2,293)
	secondary (130 mm)	600	(610)
Conning tower		269	(273)
Total protection		11,705	(11,896)



CHAPTER THREE

The Richelieu class

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The *Richelieu*-class ships were the largest battleships ever to be constructed in France and were a most innovative design, featuring high speed and good protection (including the deepest torpedo protection for a modern battleship). These ships were also to have the most unusual disposition of armament for any battleship class built during the World War II era.

France and Italy had been granted special exemptions under the terms of the Washington Treaty to build 35,000-ton battleships while the "no-construction" period of the treaty was in effect, since both countries were unable to construct new battleships during World War I or the period between that war's end and the signing of the Treaty in 1922. Diplomatic negotiations and the reluctance of their governments to provide the necessary funding prevented their construction. In 1932, after much debate, the construction of the battlecruiser *Dunkerque* was approved, but in view of a severe recession, the second battlecruiser, the *Strasbourg*, was not authorized until 1934.

There were two important events which helped to shape French naval thinking in regard to battleship construction. The German Navy had commenced the construction of its third armored ship, the *Admiral Graf Spee*, in 1933, and two more were planned. In 1934, Benito Mussolini announced that Italy would construct two 35,000-ton battleships armed with 38-cm guns. This was a setback for the British government, which had been unsuccessfully negotiating with France and Italy to have them accept a smaller battleship with 305-mm guns. France, on the other hand, was now confronted with these two new Italian ships and a possible German naval rearmament. In addition, Italy had begun the reconstruction and modernization of two of its older battleships, *Conte Di Cavour* and *Giulio Cesare*, in October 1933.

On 25 June 1934, the Conseil Supérieur met and discussed the new developments and what course of action the French Navy should take. It was agreed that the two *Dunkerque*-class battlecruisers with their high speed, large endurance, and 330-mm guns would effectively counter the German armored ships. To maintain naval balance in the Mediterranean, however, it would be necessary to construct two 35,000-ton battleships armed with 380-mm or 406-mm guns. Authorization was given for studies to be made for a battleship of 35,000 tons. The project was officially named "PN 196." On 24 July 1934, certain general requirements were established and these have been summarized in Table 3-1.

During the latter half of 1934, the Service Technique des Constructions started design studies based upon these requirements for a ship with a minimum speed of 29.5 knots. By 27 November 1934, several characteristics for the 35,000-ton battleship design were set:

The Richelieu-class battleships were the largest warships built by France. Like the Dunkerque class battlecruisers, these ships featured a high degree of concentration of armament and machinery to attain the desired characteristics. Here the Richelieu is shown in her fighting trim after her reconstruction in the New York Navy Yard in 1943.

TABLE 3-1

Design Requirements—Richelieu class

Displacement (standard)	35,000 tons (35,562 mt)
Armament	
Main	Eight or nine 15" (380-mm) or 16" (406-mm) guns disposed in triple or quadruple turrets. A twin turret should not be considered out of the question.
Secondary	Dual-purpose guns, same arrangement as the <i>Nelson</i> and <i>Dunkerque</i> .
Speed	29.5–32 knots
Armor protection	
Main side belt	14.17" (360 mm), sloped at 11.3 degrees
Upper armor deck	6.30" (160 mm) + 0.59" (15 mm)
Lower armor deck	1.57" (40 mm)
Slopes	1.97" (50 mm)
Torpedo	Same as the <i>Dunkerque</i>

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- The speed would be 31.5 knots.
- The general scheme of the *Nelson/Dunkerque* arrangement of the main and secondary armament was confirmed with 380-mm guns disposed forward.
- Protection was defined as those thicknesses sought in the original characteristics of 24 July 1934.
- The caliber of the secondary armament was to be increased, if possible, from 130 mm to 138 mm or 152 mm. In the latter case the five quadruple turrets of 130 mm, initially planned, were to be replaced by five triple turrets of 152-mm guns.
- The aircraft arrangements originally planned for the *Dunkerque* were to be applied to the PN 196 design with necessary modifications made to the hangar to embark the Loire-Nieuport 130 aircraft. Under no circumstances was the hangar to hamper the operation of the secondary armament.

The Conseil Supérieur specified that at least four twin 37-mm mounts of a new model were required for this battleship class. An installation of a multibarrel gun of the "Le Prieur" system was to be studied as a substitution for the foregoing.

It was finally decided that all possible efforts be made to start construction of the first battleship by mid 1935, its trials to be in 1938, with the ship entering service in 1939. To achieve this, the construction of the 35,000-ton battleships was given top priority in the 1935 naval program.

On 13 February 1935, the Conseil Supérieur requested that a study be made of the secondary armament. The following schemes had to be investigated:

- Five protected turrets of 152-mm guns, plus an unspecified number of 75-mm guns. Two sets of turrets were to be located port and starboard and one turret located on the centerline.
- Four protected turrets of 152-mm guns, plus an unspecified number of 75-mm guns. A set of turrets were to be located port and starboard, and two were to be located on the ship's centerline.
- Five protected turrets of 130-mm guns and an unspecified number of 75-mm guns.

The purpose of the study was to determine the number of 75-mm guns that could be carried.

By 12 April 1935 some final decisions were made regarding France's first 35,000-ton battleship design, and problem areas were identified for further study. Although the final characteristics were not yet established, the following was decided:

- The secondary armament was to consist of five triple turrets of 152-mm guns which could be loaded and capable of firing up to 90 degrees or more elevation. The speed and acceleration for the training and elevating mechanisms were to be the same as those used in the 130-mm turrets on the *Dunkerque*. It was stressed that these guns had to be dual-purpose. The armor protection featured thicknesses that varied from 90 mm to 120 mm.
- Studies were to be undertaken urgently to determine the composition of the "close in" antiaircraft defense which was to consist of either 75-mm guns of a new model with a 90-degree elevation, automatic 37-mm guns, a combination of these two, or guns of an intermediate caliber. It was understood that the total weight of gunnery for the "close in" weapons system should not exceed 100 tons.
- Research had to be conducted with the most elaborate means to diminish the overweight problem.

The excessive weight in these battleships was to be a cause of concern throughout their careers and would ultimately lead to the redesign of the *Jean Bart* during the post-World War II period. During this early stage of design the following measures were sought:

- The main transverse armored bulkheads were to be constructed of class A 147-mm armor plate instead of 160-mm class B or Special Treatment Steel.
- The use of new boilers with supercharged combustion was authorized for study because of a potential 300 metric-ton weight reduction. Experiments were being conducted at that time by Indret to determine whether such a scheme was practical.
- A reduction of 20 mm was proposed in the side armor belt (360 mm to 340 mm) at an inclination of 11.3 degrees.
- It was proposed to determine whether 200-250 tons of armor protection could be removed from the five turrets for the 152-mm guns.
- The last two measures were to be instituted only if the first two measures could not produce the desired weight reduction.

By November 1934 it had been determined that a quadruple turret of 406 mm would not really be possible. To retain the protection desired and a speed of 29.5 knots, the main armament had to be eight 380-mm guns in two quadruple turrets or six 406-mm guns in two triple turrets. In the design schemes, the main armament was grouped forward and the secondary was aft. Although the Conseil Supérieur preferred a 35,000-ton battleship armed with 406-mm guns, design data based on the *Nelson* indicated that such a ship with nine guns in triple turrets could not be built within Treaty limits with the speed and protection sought. Also, there would have been a long development time for triple turret loading and gun elevating mechanisms as compared with a workable and successful 330-mm quadruple turret in the *Dunkerque* and *Strasbourg*.

Discussions concerning the dual-purpose secondary armament were important, since the choice of caliber would influence the number and caliber of the "close in" machine-gun battery. It was decided that the prospects for the development of a dual-purpose gun of a caliber between 130-138 mm were much less than for a caliber of 152 mm. At the same time it was also realized that these guns could not be equipped with a fixed round (i.e., shell and cartridge case combined as a single unit).

The "close in" weapons system (i.e., 37 mm, 75 mm, etc.) arrangement was difficult because it had to have complete hemispherical coverage, but the blast interference of the main and secondary armament presented an extremely difficult problem since it was virtually impossible to avoid. These guns had to be located in zones free from blast unless the firing arcs of the larger guns were restricted, which was unacceptable. It appeared that the only sections of the ship where the light antiaircraft weapons could be placed without any problems were the foredeck or those sections of the superstructure between the 152-mm turret locations. In any event, such a disposition was very cramped and severely limited the number of antiaircraft weapons.

Some thought was also given to the use of cemented armor of 140/150-mm thickness on the upper armor deck instead of the 170/150-mm noncemented armor. Such a reduction of armor plate thicknesses would have yielded a weight savings of 200 to 300 metric tons. It was felt that cemented armor would also provide better protection, but difficulties were still being experienced in its fabrication. Experiments continued at Brest and Gâvre to arrive at a definitive decision.

With the conclusion of discussions, the baseline design had the characteristics in Table 3-2. The characteristics called for the placement of a compartment, 11 meters long, between the two main turrets to diminish the probability of both turrets being silenced simultaneously. Also, it was specified that the turrets, magazine fittings, and ammunition hoists for the 380-mm guns be based on the drawings of the 330-mm main armament of the *Dunkerque* and *Strasbourg*.

TABLE 3-2

Preliminary Design Requirements—4 April 1935

Standard displacement	37,960 tons (38,580 mt)
Full-load displacement	44,385 tons (45,110 mt)
Waterline length	794' (242 m)
Waterline beam	108.53' (33.08 m)
Draft (design)	30.09' (9.17 m)
Armament	eight 15" (380-mm)/45-caliber guns in two quadruple turrets disposed forward. fifteen 6" (152-mm)/55-caliber guns in five triple turrets eight 1.46" (37-mm) guns in four twin mounts and 24 0.59" (13.2-mm) machine guns in six quadruple mounts five Loire-Nieuport 130 aircraft
Speed	31.5 knots at the normal displacement (1/3 fuel condition)
Shaft horsepower	147,950 (150,000 mhp)
Endurance (6,300 tons of fuel)	14,300 miles at 15 knots 9,900 miles at 18 knots
Protection	main belt—13.39" (340 mm) sloped at 11.3 degrees armor decks—6.69" (170-mm) magazines 5.91" (150-mm) machinery

The secondary armament was to be 152-mm dual-purpose guns in triple turrets which would be capable of firing to an elevation of 90 degrees. One turret was to be located on the ship's centerline abaft the engine room, two turrets abreast, and two turrets amidships. The secondary battery was to be provided with two directors so that the target could be shifted instantaneously.

The antiaircraft battery was to consist of four twin turrets of 37-mm automatic guns. Six or eight quadruple machine-gun mounts of 13.2 mm was to complete the battery.

The underwater protection had to be sufficient to withstand a torpedo with a 300-kg warhead, exploding anywhere along the armor box.

The horizontal protection had to be sufficient to protect against an armor-piercing bomb of 500 kg dropped from an altitude of 4,000 meters.

The standard displacement was still too great, and on 12 April 1935 an urgent call was made for further attempts to reduce it. A decision was made to use the new pressure-fired boiler, since the tests at Indret had been successful. This meant that the number of firerooms could be reduced from three to two and the number of boilers per fireroom increased from two to three since the Sural-Indret (Norguet) boiler was very compact. This permitted the rearrangement of the propulsion plant, which would reduce the length of the armor box. It was also decided to add a second turbogenerator room aft, just forward of the 152-mm gun magazines. These changes shortened the armor box by 4.85 meters.

Further attempts were made at reducing the standard displacement since the waterline at the full-load displacement was dangerously close to the lower armor deck. After much discussion it was decided to reduce the side armor from 340 mm to 330 mm and increase the armor slope from 11.3 to 15.5 degrees so that the new armor thickness of 330 mm would be equivalent to the 340 mm at the 11.3 degree slope. There were armor reductions on the main transverse armor bulkheads at the forward and after ends of the armored citadel. The sides of the conning tower were also reduced from 350 mm to 340 mm, while the armor for the secondary armament was reduced to 100 mm for the barbettes, 120 mm for the face plates, and 70 mm for the roofs. Any further reductions in the ship would have compromised the design objectives of protection and speed sought by the Conseil Supérieur. Investigation of the protection provided the main-battery turrets indicated that the armor thicknesses of 420 mm on the face plates, 280 mm on the sides, and 170 mm over the gun chamber were insufficient. With the increased probability of air attack and the use of 380-mm guns on the German *Bismarck* and 381-mm guns on the *Vittorio Veneto*-class battleships, more armor protection was deemed necessary for these portions of the main-battery turrets. It was thought that the foregoing reductions in armor and the use of pressure-fired boilers would reduce the standard displacement enough to permit the increase in main-battery-turret protection.

After the preliminary studies were completed, Parlement approved the construction funds. The *Richelieu* was to be built by the Brest Navy Yard and the *Jean Bart* jointly by the Penhoët and Loire Shipyards in St. Nazaire. The ships' design and construction benefited immensely from similar experiences with the *Dunkerque* and *Strasbourg*. The characteristics of the final design, as constructed, are summarized in Table 3-3.

In January 1935, France renounced the Washington Treaty and proclaimed that she would no longer abide by its limitations regarding her battleship tonnage. That following June, Great Britain negotiated directly with Germany regarding the latter's naval rearmament without consulting France. A naval pact was signed in London on 18 June 1935 that permitted German construction of two 26,000-ton "battleships," in addition to other combatant types. In the meantime, due to the diplomacy of Prime Minister Pierre Laval, relations between France and Italy deteriorated. France was now suddenly confronted with two naval opponents, but still felt confident that with a strong Anglo-French alliance, she could successfully cope with the combined German and Italian Navies.

In December 1935, the second London Naval Conference convened, and at its conclusion France was one of its signatories. When Japan did not sign this agreement by the prescribed date, the French government invoked Article 25 of the Treaty—the "escalator" clause. France chose to conform to the existing limits of the treaty, how-

TABLE 3-3

Final Design Characteristics—Richelieu Class

Standard displacement*	37,832 tons (38,450 mt)
Full-load displacement*	44,708 tons (45,438 mt)
Waterline length	794' (242 m)
Waterline beam	108.53' (33.08 m)
Draft (design)	30.09' (9.17 m)
Armament	Eight 15" (380-mm)/45-caliber guns in two quadruple turrets disposed forward. 1938—Fifteen 6" (152-mm)/55-caliber guns in five triple turrets. 1940—Nine 6" (152-mm)/55-caliber guns in three triple turrets. Twelve 3.94" (100-mm)/45-caliber guns in six twin mounts. Twelve 1.46" (37-mm) guns in four twin mounts and twenty-four 0.59" (13.2-mm) machine guns in six quadruple mounts. Three Loire-Nieuport 130 aircraft and two catapults.
Speed	31.5 knots at the normal displacement (1/3 fuel condition)
Shaft horsepower	147,950 (150,000 mhp)
Endurance	10,000 miles at 15 knots
Protection	Main belt—12.99" (330 mm)—class A sloped at 15.5 degrees. Armor decks—6.69" (170 mm) Magazines—class B 5.91" (150 mm) Machinery—class B

* Displacement figures based on the 1940 Weight Report of the *Richelieu*.

ever, because she was fearful of a surge in European naval construction and was "desirous of limiting as far as possible the extent and eventual consequences of this first departure from the treaty." Nevertheless, Germany began the construction of the *Bismarck* and *Tirpitz* in 1936, and Italy ordered two more *Vittorio Veneto*-class battleships in 1937.

In 1938, representatives of France, the United States, and Great Britain met in London to discuss the extent of the departures from the treaty which they deemed desirable. Great Britain desired that gun caliber be limited to 406 mm and a standard displacement to 40,000 tons. These were the important design limits of the British *Lion*-class battleships in 1938. France desired 406-mm guns and 35,000 tons, but British representatives were quick to point out that such limits were not compatible with a 30-knot speed. The United States pushed for an upper limit of 45,000 tons on displacement and the 406-mm gun. After much discussion, the limits were established at 45,000 tons and 406 mm as of 30 June 1938. It was not, however, until after the Munich Accord in September 1938 that the French Navy decided to order the construction of two more 35,000-ton battleships—the *Clemenceau* and *Gasconne*. By 1938, the threat of air attack was even greater, and it was decided that more antiaircraft guns would be required. Some difficulties were being experienced with the ammunition loading of the 152-mm guns at 75 degrees, and the maximum elevation of 90 degrees sought in the design particulars had to be reduced to 75 degrees. This reduced their value as heavy antiaircraft guns, necessitating the addition of six twin mounts of 100-mm dual-purpose guns to reinforce the heavy antiaircraft gun battery of the *Richelieu* and *Jean Bart* and the deletion of the two forward 152-mm triple turrets. In

addition, the number of 37-mm guns was increased to twelve, with two enclosed mounts being placed just forward of Turret II. This was a relaxation of early considerations on the placement of such guns, but space in these ships for antiaircraft guns with clear arcs of fire was limited. Moreover, based upon preliminary weight estimates from the Brest Navy Yard, there was an indication of a severe overweight problem in the *Richelieu*. It was decided to reduce the number of triple 152-mm turrets in the *Clemenceau* from five to four and to delete the aircraft complement and hangar facilities. This permitted the addition of six 100-mm mounts, two quadruple automatic 37-mm mounts, and three quadruple 13.2-mm machine-gun mounts in areas less susceptible to blast effects and with improved arcs of fire. The elimination of the aviation facilities and the 152-mm triple turret offset the weight increases in the antiaircraft battery.

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In the *Gascogne* a major redesign was undertaken. During 1939, as the *Richelieu* neared completion, the severe overweight condition had become acute. The Loire firm was authorized to make studies to determine a better arrangement of the antiaircraft guns and to recommend ways of reducing the weight. The hull form was to have the same dimensions and geometrical properties as the three previous ships. Whereas the *Richelieu*, *Jean Bart*, and *Clemenceau* were to have had their main armament forward, the *Gascogne* was to revert to a more conventional armament arrangement with one main and two secondary turrets forward and one main and one secondary turret aft. The antiaircraft battery was now disposed in a better position with equal coverage fore and aft. The antiaircraft battery now included, in addition to the nine 152-mm guns, eight 100-mm guns in four twin mounts; the machine-gun battery was the same as in the *Clemenceau*, but free from the blast effects of the main and secondary guns. The arrangement of the antiaircraft guns was such that the 152 mm, 100 mm, 37 mm, and 13.2 mm could be fired in isolated groups and their fire controlled by four directors. The redistribution of the armament increased the length of the armor box by 3.65 meters, but this was offset by reducing the side armor belt to 320 mm and modifying the splinter protection.

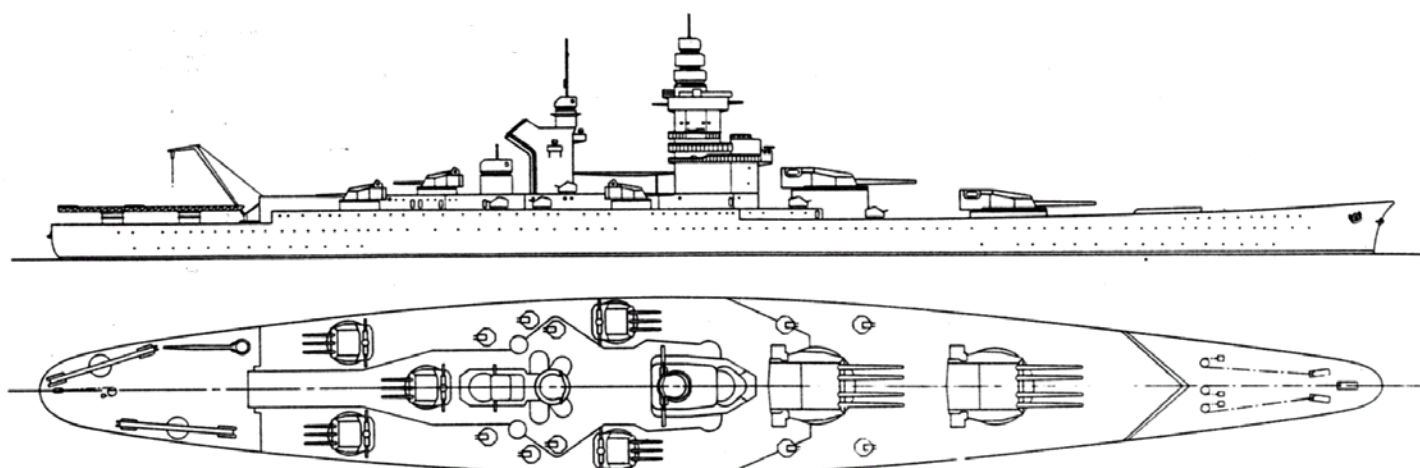
Although the most striking change in the *Gascogne* was the redistribution of the main armament, an equally important alteration took place with the propulsion plant, which was shifted forward 19.4 meters because of the addition of a main-battery turret aft.

An aircraft complement was reintroduced in the *Gascogne*. Two aircraft were to be stowed in a below-deck hangar at the stern free from the blast of the 380-mm guns. A single catapult was planned.

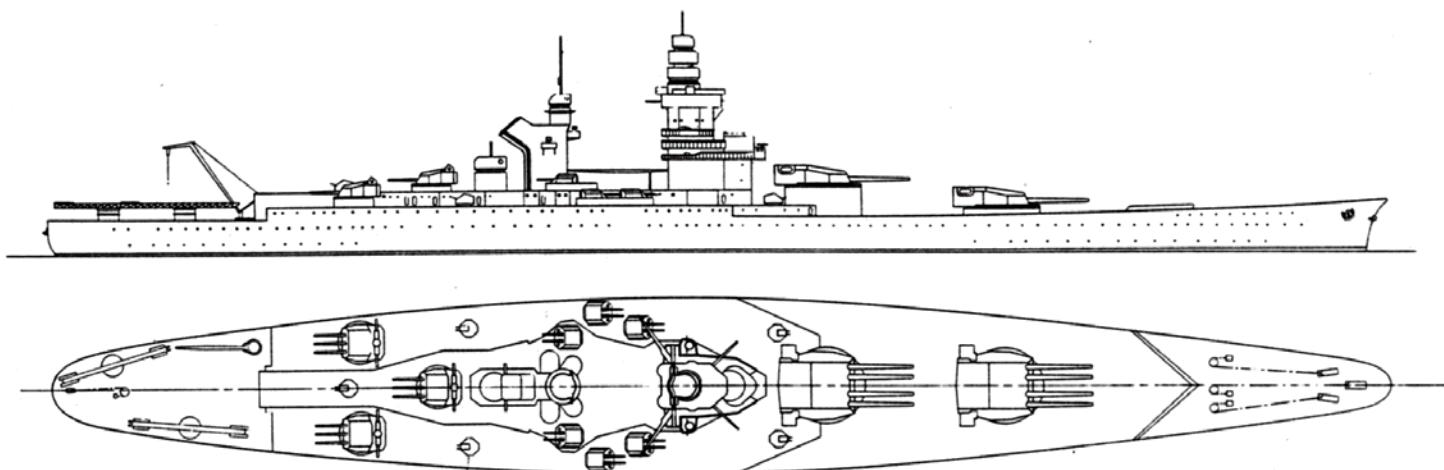
On 15 April 1940, the French Navy proposed, and the prime minister approved, the construction of two additional ships of the *Gascogne* type. One hull was to be laid down in 1941, and the other in 1944. These plans were abandoned with the fall of France in June 1940.

Richelieu—Operational History. When Germany invaded France in May 1940, three 35,000-ton battleships were building in French shipyards, with the *Richelieu* in the final stages of outfitting. Her keel had been laid at the Brest Navy Yard on 22 October 1935, and she was floated in the graving dock on 17 January 1939. The long construction period was due to design studies, design developments and changes, and manpower and shop limitations. The hull was erected in three sections to avoid a long-term use of the Laninon Drydocks, which were used also for overhauling and completing large ships. The center section was built in Salou Drydock 4 at the same time the *Dunkerque* was being completed in another dock.

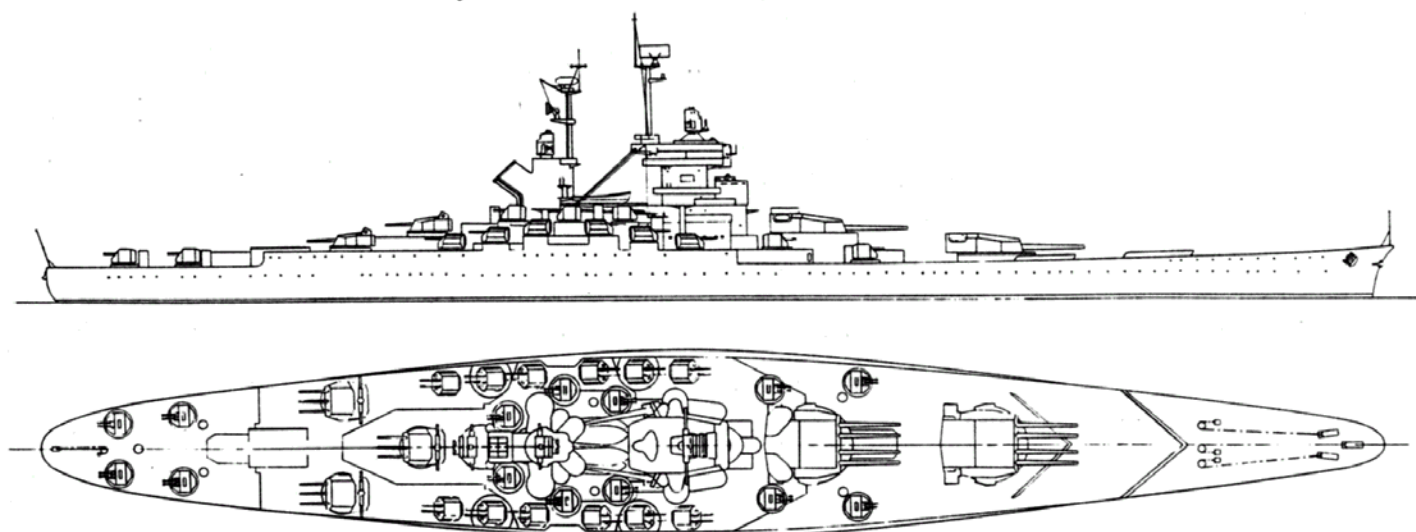
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Outboard Profile and Topside View (*Richelieu*—Revised 1935 design)

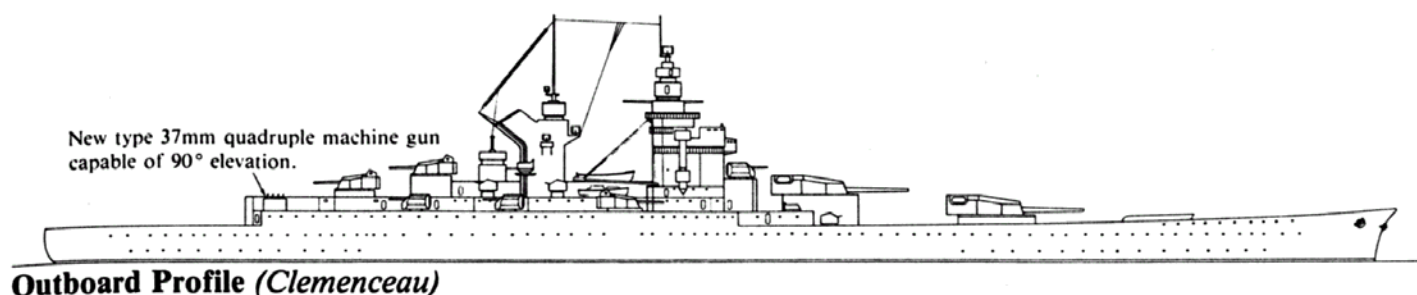


Outboard Profile and Topside View (*Richelieu*—1940)

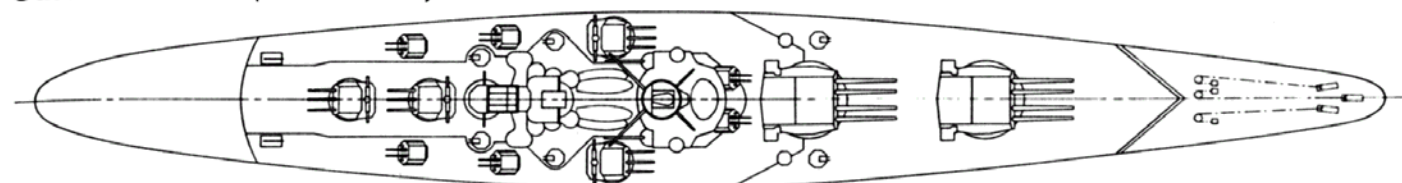


Outboard Profile and Topside View (*Jean Bart*—1955)

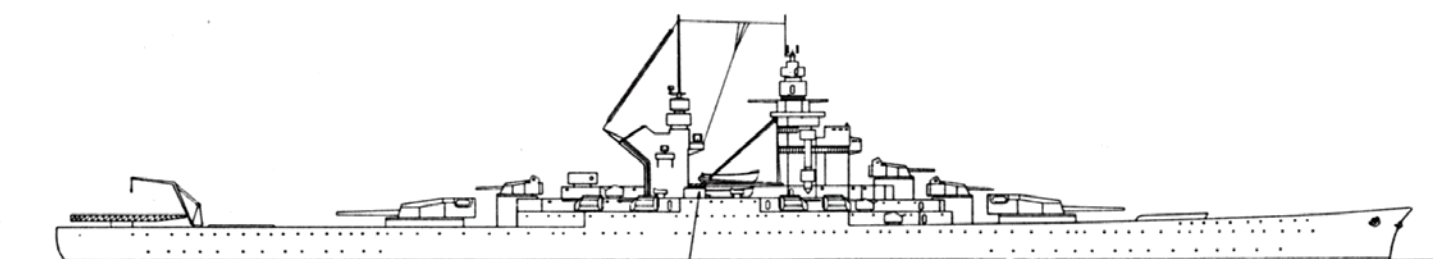
New type 37mm quadruple machine gun capable of 90° elevation.



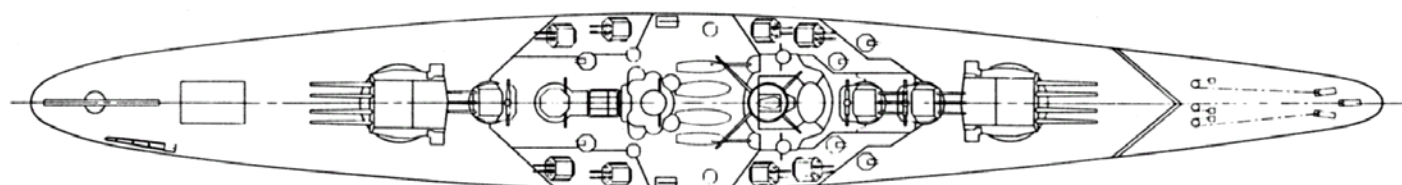
Outboard Profile (Clemenceau)



Topside View (Clemenceau)



This was to be a new model 37mm quadruple machine gun mount with 90° elevation.



Outboard Profile and Topside View (Gascogne)

After that ship was floated, the *Richelieu* was moved into the larger Laniron Drydock, where the bow and stern sections were attached. The bow section was 52 meters long. The stern section—that part of the ship aft of the after steering room bulkhead—was shorter.

After World War II began in September 1939, outfitting work was accelerated. Dockside turbine trials were held on 14 and 15 January 1940, the propulsion plant and degaussing gear were tested on 4 April, and dockside trials were run on 7 April, with the plant developing 100,000 metric horsepower. On 14 April the first acceptance trials were run off Brest, with speeds of 18.5, 22.7, and 30 knots.

On 5 May 1940, the British government sent the Duke of Kent to check on the ship's completion. The Royal Navy was anxious to have her available to augment the strength of the Home Fleet, as the *Bismarck* and *Tirpitz* were nearing completion.

The day Germany invaded France, the captain of the ship met with shipyard personnel to expedite work so that the main-battery guns could be tested by 15 June. Turret training and the elevating gear was tested on 31 May in accordance with procedures cited in the ship's specifications; some difficulties were found in the operation of the equipment with a ten-degree static ship list, and these had to be corrected. The following day five 100-mm guns were ready to fire, four twin 37-mm machine

guns were being mounted, and the main rangefinders were being worked on. A week later the captain informed the French Admiralty, where there was concern over the increasing menace of German air attack, that the work-force available could not complete the magazines by 15 June.

On 13 June the *Richelieu* ran speed trials, making 32 knots on normal maximum power and 32.6 knots on the maximum overload of 179,000 metric horsepower on a displacement of 43,000 tons. Firing of the 380-mm and 100-mm guns, limited to six rounds per gun, was insufficient to prove their combat readiness. The main battery, because of the makeshift loading arrangements, required at least fifteen minutes to load. The ship returned to Brest on 14 June to load all available ammunition. That same day German aircraft first attacked Brest and the *Richelieu* fired on them thirteen different times.

On 15 June the French Admiralty ordered the *Jean Bart* and *Richelieu* to be ready to sail to a British port, and to load all equipment necessary for their completion abroad. The *Richelieu* loaded as many 380-mm projectiles as possible, as their production would be difficult outside France. Powder cans, which were easier to manufacture, took a lower priority. In two days, a total of 269 projectiles and 48 powder cans, plus 1,770 rounds of 100-mm and 2,030 rounds of 37-mm ammunition, and provisions for two months were loaded. The four hundred 380-mm rounds and fourteen hundred 152-mm rounds remaining were to be moved out in cargo ships.

German air attacks on Brest intensified on 18 June. At 1235 the tug *Provençal* struck a mine and sank within a ship's length of the *Richelieu*. Before dawn that day, the French Admiralty canceled the order to sail to a British port; all French warships were to sail to French colonies, and under no circumstances were any ships to be left afloat to fall under German control. The *Richelieu* was ordered to Dakar under escort and sailed that night, with the destroyers *Fougueux* and *Frondeur*; she carried all the cadets of the French Naval Academy and several engineers and key personnel of the Génie Maritime (the Naval Staff). The new destroyer *Fleuret* relieved the other escorts off Cape St. Vincent.

The *Richelieu* reached Dakar on 23 June; there it was estimated ten days of work would be required to adjust the main-battery guns and to ready the 152-mm guns for automatic fire. In fifteen to twenty days, the 152-mm guns would be operational with a simplified fire-control set up, provided ammunition was available. In Dakar at the time was the British aircraft carrier *Hermes*. Her captain immediately paid a visit to the *Richelieu*, trying to persuade the French to sail with him to Freetown. In the meantime, the political situation in Dakar was not settled due to the pending Armistice and thus the governor ordered all French warships in the harbor to sail to Casablanca or Port-Étienne. On 25 June the *Richelieu* left Dakar and headed towards Casablanca at a speed of 20 knots. When the captain of the *Richelieu* requested that he be given permission to enter Casablanca, however, he was advised by order of Admiral Darlan to return to Dakar. While off Port-Étienne on 26 June, the HMS *Dorsetshire* sighted the French battleship and began to shadow her. Around midnight of 27 June the two ships parted, and later that day the *Richelieu* safely reached Dakar.

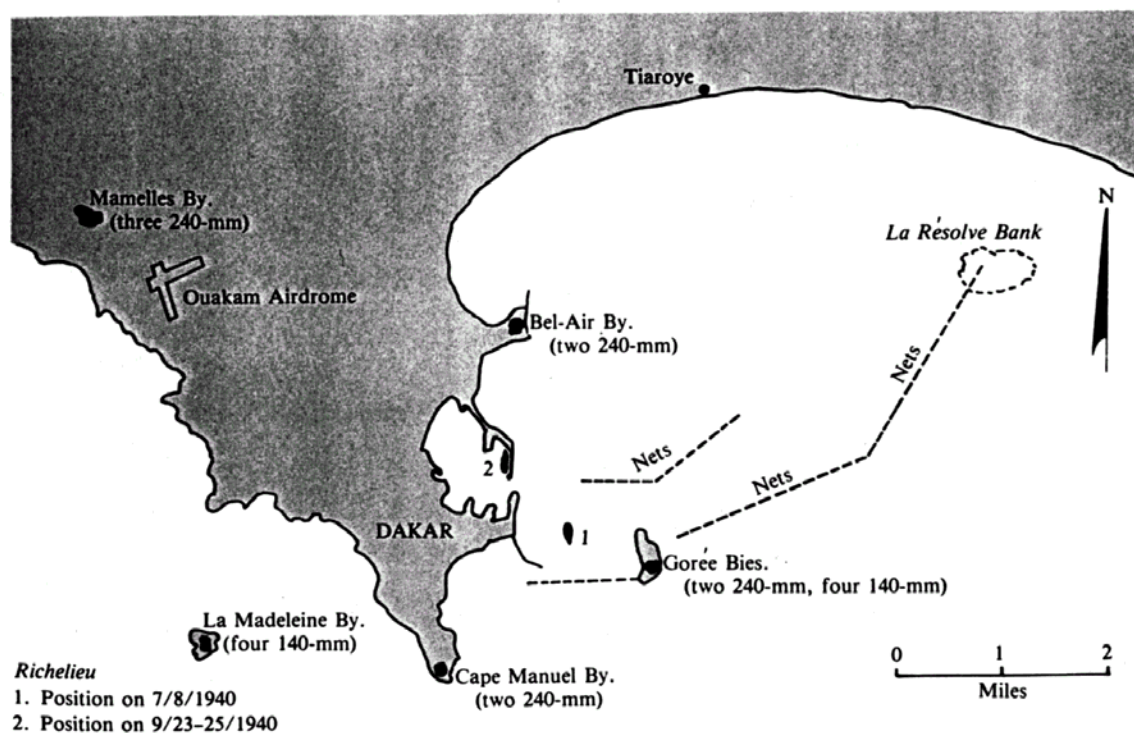
On 3 July 1940, the British sent an ultimatum to French forces in Africa; it was ignored. All French warships were given orders to fight if fired upon. Admiral Planson, the commander in chief in French West Africa, refused to communicate with the British warships and warned that if they approached Dakar they would be shelled.

Torpedo and depth-charge damage. Four days later, a motor launch from the British carrier *Hermes* slipped over the harbor defense boom, dropped six depth charges near the *Richelieu*, and withdrew unnoticed. The charges were dropped in such shallow water (15.4 meters) that they did not explode.

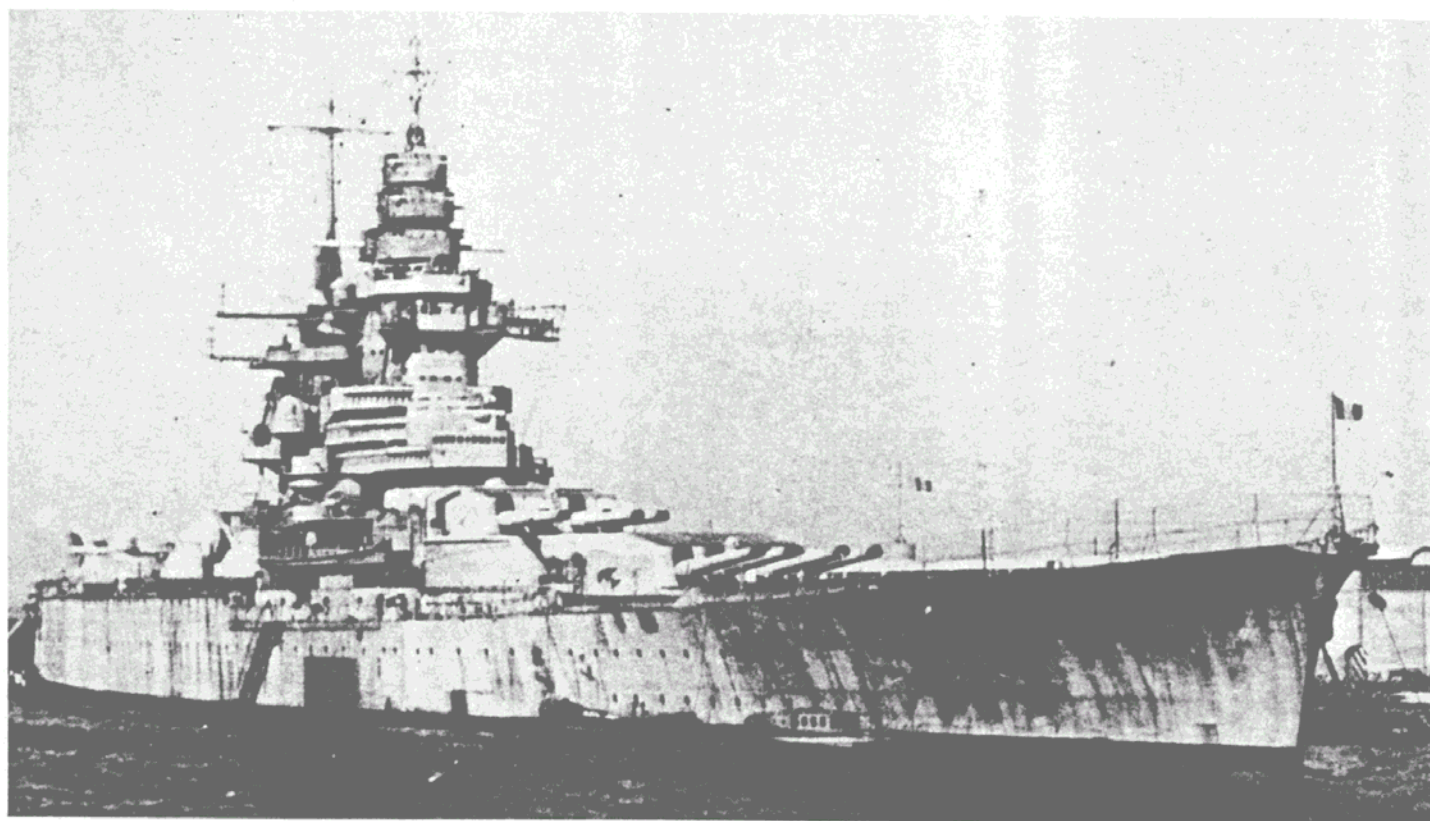
The *Richelieu* was moored about half-way between Gorée island and Dakar's outer jetty, because it was feared that if she was in the harbor, she could not sail quickly. To protect her, five cargo ships had been moored around her, facing the less protected side of her mooring.

At 0500 the crew began to prepare the battleship to leave her anchorage. It was the plan of her captain to take her to the outer roads and wait there until the situation cleared. However, six Swordfish torpedo bombers from the *Hermes* suddenly attacked the *Richelieu*; none of them were shot down. These British planes carried torpedoes with a charge of 450 pounds of TNT, magnetic pistols, and a depth setting of 11.55 meters. The draft of the *Richelieu* at the instant of the attack was 10.4 meters. The planes attacked from the port side; although there were no direct hits, one torpedo passed under the stern and exploded beneath the starboard side. It has never been firmly established whether this torpedo exploded after it passed under the keel, or whether it struck one of the depth charges dropped earlier by the motor launch from the *Hermes*. The French official report on the incident indicates that "the ship was struck by one or two torpedoes." The evidence, however, does show the possibility that one torpedo passed under the stern, triggering the magnetic pistol and detonating the depth charges dropped by the motor launch. Such a sympathetic detonation of charges is possible within 50 meters from the point of explosion. Certainly the depth charges would have been close enough to be affected, since the ship had not been moved during the period between the depth-charge placement and the torpedo attack. The detonation was very severe and the ship shuddered and tossed at her moorings.

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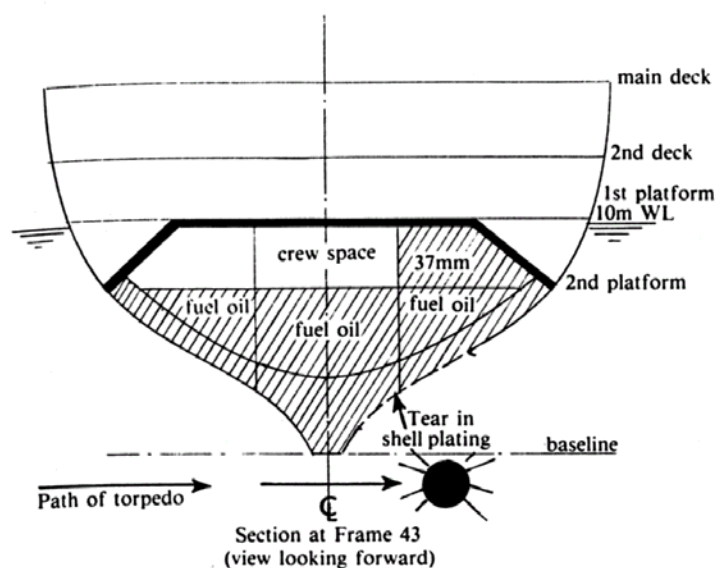
The location of the *Richelieu* in the African port of Dakar in July and September 1940. On 8 July 1940, the French battleship was anchored at (1) and surrounded by cargo ships and torpedo nets. Two land masses were to her sides. Nonetheless, Swordfish torpedo planes from the *Hermes* managed to release their torpedoes during a dawn attack. One of these damaged the stern and immobilized the *Richelieu*. Sometime during August 1940, the *Richelieu* was moved to a quay (2) in Dakar where Anglo-Free French forces found her on 23-25 September 1940.



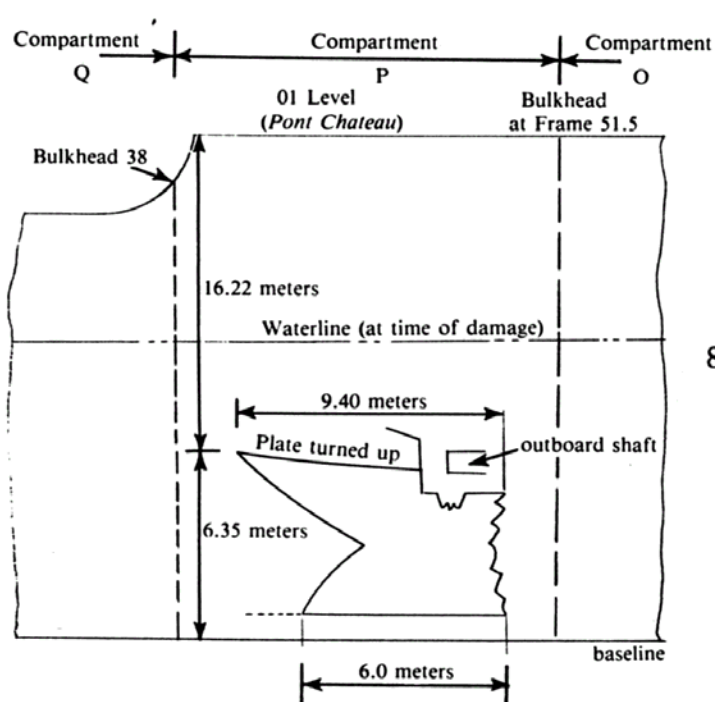
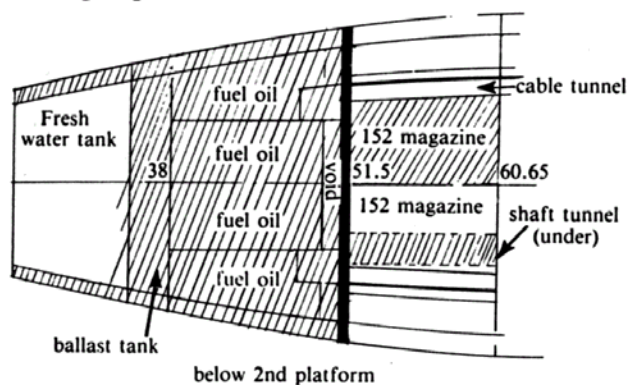
The Richelieu is shown in Dakar in 1941. The ship had been attacked there by British torpedo planes on 8 July 1940 and sustained severe torpedo damage in her stern. On 23-25 September 1940 she opposed an Anglo-Free French invasion of Dakar and incurred some additional damage. The starboard inner barrel of Turret II was damaged by a defective 380-mm shell exploding within. The gun is missing in this photo. (Musées de la Marine)

Official reports of the torpedo explosion indicate its great force and hypothesize that the shallow water depth (15 meters) produced a refraction or depth-charge effect on the ship. There is some indication that the ship also exhibited a whipping response as there is evidence of damage to electric motors, aerials, and rangefinders some distance from the point where the charges detonated. The torpedo explosion occurred midway between the inner and outer fairwaters of the starboard shafting. Damage was as follows:

- The keel was severely twisted for a distance of 25 meters. The bottom and side shell on the starboard side were severely deformed to the turn of the bilge.
- The outboard edge of the top of a fuel-oil tank was buckled in way of the explosion and over the length of the damage described. The width of transverse buckling was approximately 9 meters by 5 meters.
- There was some structural deformation in an intermediate longitudinal bulkhead in Section P. By 10 July 1940 this had permitted the seepage of oil into a crew living space and a 37-mm magazine on the third deck (2^e Faux Pont). Some oil seeped into the starboard shaft alley in section O through a damaged bulkhead stuffing gland. Oil also leaked into wireways, the port 152-mm magazine in section O, and the aft turbogenerator compartment.
- There was a severe misalignment of the inner starboard shaft due to the displacement of the shaft tube, and a fracture in the stern casting.



Flooding Diagram



A view of hole normal to shell plating

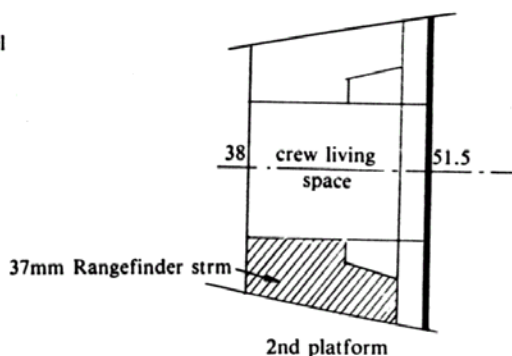
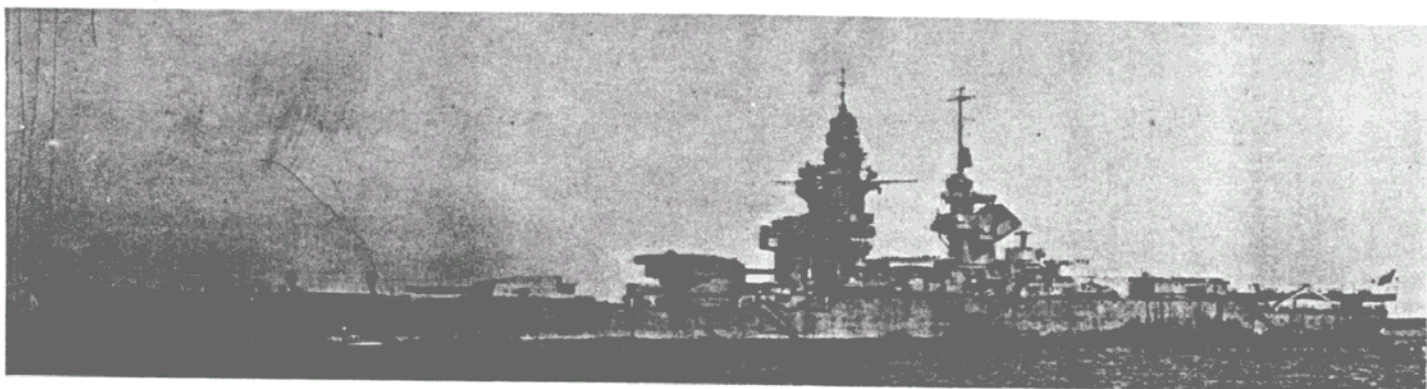
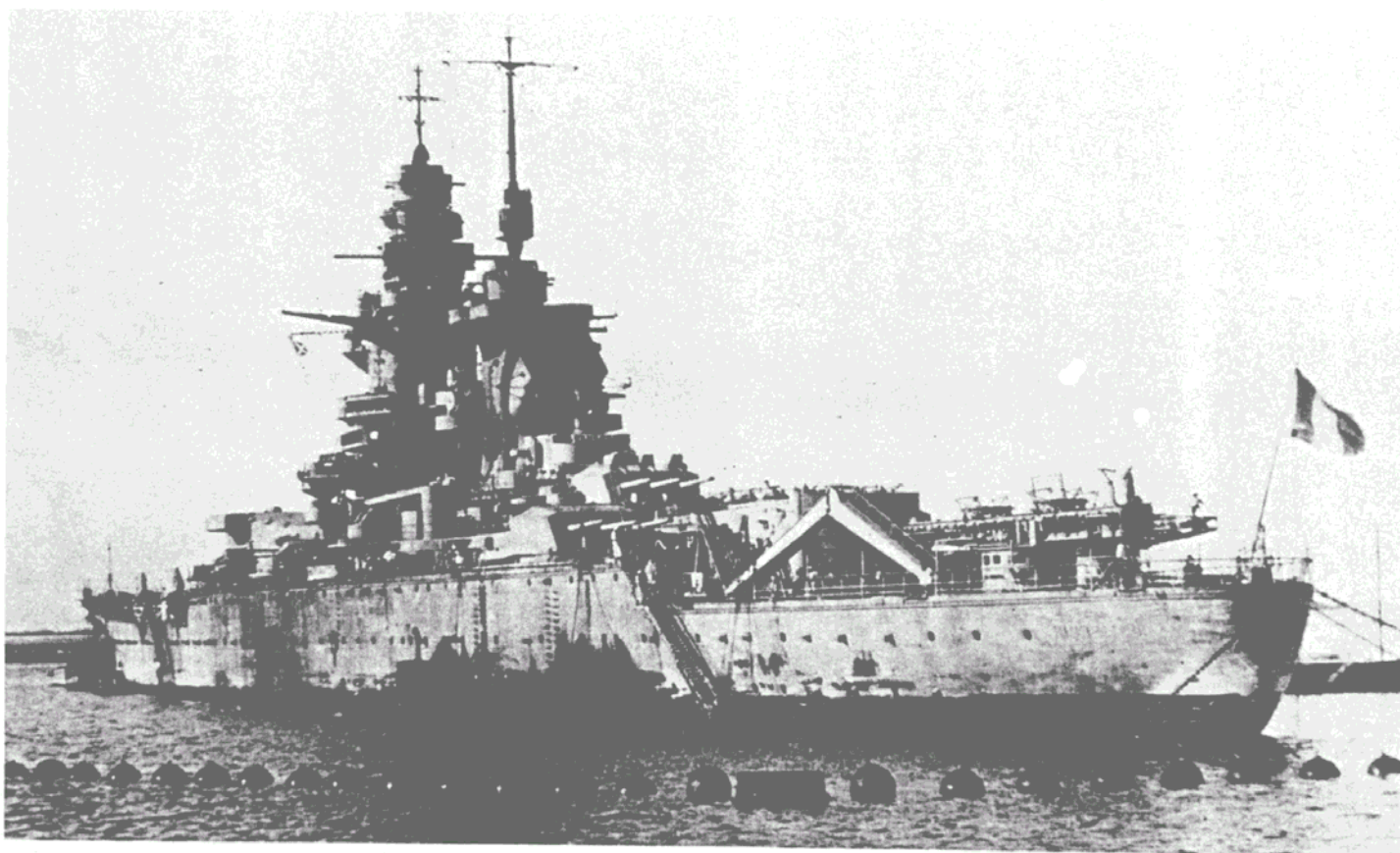


Figure 3-1. The Richelieu was torpedoed on 8 July 1940 at Dakar by aircraft from the British carrier Hermes. One of the many tragedies resulting from the sudden collapse of France resulted in the outbreak of hostilities between the Royal Navy and their former allies. The British were determined, no matter what the price, that the French Fleet not fall under the control of the German Navy. The French were equally adamant in their insistence that they control their ships, not the British. The result varied, ranging from the demilitarization of the French Navy units at Alexandria to combat engagements between British and French units in North Africa. The British had demanded that the French warships be demilitarized or join the British in continuing to fight the Germans. The Richelieu was the prize warship that the Royal Navy wanted on their side, for she alone was a complete match for the Bismarck, which was about to go into service.

The torpedo from the Hermes aircraft passed under the fantail from port to starboard, detonating under the stern of the Richelieu just abaft the after armored bulkhead. The series of sketches presented here depict the effects of this detonation:

- Section at Frame 43 looking forward shows the extent of the tear in the hull plating.
- The flooding effect diagrams for the 2nd platform and hold show the extent of flooding resulting from the torpedo damage. It should be noted that the explosion occurred near the point of emergence of the starboard outer shaft. Its shaft alley was flooded, and the shaft itself was severed. Severe damage was also done to the inner shaft at its shaft strut, as well as buckling its stern tube.
- The shell expansion of the area of damage shows the true projection of the hole ripped in the shell plating by the torpedo explosion.

- There was a transverse and longitudinal failure of the supporting structure for the stern casting of the aft shaft strut.
- There were some tears and buckling of plates in the side shell, and these caused minor flooding in some side compartments aft of the armored citadel. In the vicinity of the torpedo detonation, the side plating was torn open and bent inward.
- Flooding was confined to two main fuel tanks in the region of severe deformation to the side shell and keel. Normally these were filled with fuel oil, but because the *Richelieu* was confined to Dakar, there was no need for these tanks to be completely filled.



These two photos of the *Richelieu* were taken on 25 July 1940 while the battleship was still anchored off the city of Dakar. Note the torpedo nets surrounding the ship and the damage to the stern.

- There was some structural deformation in the barbettes of the wing 152-mm triple turrets.
- The motors supplying the 460V electrical current to the main turrets were put out of action.
- The main radio aerial was broken.
- The steering-gear motors were inoperable.
- The main fire-control director on top of the bridge tower and two directors for the 152-mm guns were out of action.
- The main turbine clearances were affected, necessitating a realignment and thorough overhaul.
- Ventilator mountings were broken, and the fan units shifted off their foundations.

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Damage and flooding were severe. The starboard inner shaft was completely immobilized; the outer shaft could be turned only with great difficulty. Deformation of several main watertight bulkheads caused some spaces in main watertight compartments O and P to flood in varying degrees with a combination of fuel oil and salt water; the ship trimmed by the stern by 0.6 meters. The steering gear was disabled; however, the rudder could be turned by the hand steering gear. (See figure 3-1.)

Progressive flooding continued for several days, and the ship settled deeper into the water. By 10 July 1940 emergency repairs to the *Richelieu* had been completed, halting the further ingress of water and fuel. The following spaces were flooded:

- In compartment P, the crew living spaces on the lower decks, the 37-mm machine-gun magazine, and the inboard shaft alley.
- In compartment O, the cableways and their extensions into compartment P were flooded with fuel oil; the 152-mm magazine and the after turbogenerator room were partially flooded with salt water and fuel oil.
- The inboard shaft alley was flooded.

The most serious damage occurred in the region of the stern casting and the stern tube for the inner starboard shaft. Although the shaft was not broken, it had sustained a severe deflection in compartment P and a fracture in the stern casting near the intersection of the inner shaft with the shell plating. The only shipyards in Europe or Africa that could handle such repairs were either under German or British control, and the return of the *Richelieu* to Mediterranean ports meant the strong possibility of encountering British warships en route, as the Straits of Gibraltar were blocked by British forces. Moreover, the ship was restricted to a maximum speed of 20 knots, and there was only limited rudder control—by emergency means.

Temporary repairs, mostly of a makeshift type, were made in Dakar. A timber cofferdam was constructed in way of the damage to the shafts and stern casting to limit any further damage. Flooded compartments not adjacent to damaged portions of the side shell were sealed and pumped out. After they received a 28 August 1940 report on the *Richelieu*, it was apparent to the French Admiralty that the ship could not sail from Dakar under conditions then present. The report indicated that the turbines were misaligned; the main 380-mm gun director was not in operation; two 152-mm directors were not operational; there were three points of flooding some 9 meters below the waterline; there was difficulty in maintaining electrical current; there was damage to the cabling for the 100-mm guns; there was structural deformation in the 152-mm turrets; there were problems with the operation of flooding and drainage pumps and some interruptions in the ventilation system.

When the *Richelieu* left Brest on 18 June 1940, her guns had not been completed or test fired. Since that time and into September 1940 she had had no occasion to test her 380-mm guns. When she reached Dakar, she had powder for only forty-eight 380-mm shells. Between June and September, the Service de l'Artillerie Navale replaced the missing powder with powder taken from the *Strasbourg*.

Free French and British attempt to invade Dakar. Although the *Richelieu* had sustained some severe stern damage, her guns were intact, and in combination with the coastal batteries, she provided Dakar with excellent gun coverage. The *Richelieu* was moved from her position in the harbor to a quay, with her bow facing seaward. This is where the Anglo-French invasion forces found her on the morning of 23 September 1940.

General Charles DeGaulle and his British allies had hoped to wrest Dakar from the control of Vichy, and in doing so, bring the *Richelieu* under the control of the Free French forces. The battleship would then be sent to the United Kingdom for permanent repairs and completion. On 23 September the invasion force approached a fog-shrouded Dakar. Trailing the Free French forces were the British battleships *Barham* and *Resolution*, the aircraft carrier *Ark Royal*, cruisers *Devonshire*, *Delhi*, *Cumberland*, and *Australia*, and numerous smaller craft. At first, the Free French forces attempted a negotiated settlement, but their emissaries were rebuffed and even taken prisoner. At 0610 the battleship *Richelieu* fired on Swordfish reconnaissance planes from the *Ark Royal*. At 1000 a coastal battery engaged a British destroyer, and a battle soon commenced. During the afternoon, General DeGaulle's attempt to land his troops at Rufisque was called off.

On board the *Richelieu* on 23 September, only Turret II was ready for action. Two triple 152-mm turrets were ready for action, while a third still lacked ammunition. All the 100-mm guns were operational.

On 24 September the battle resumed. At 0715 the *Richelieu* was bombed by British carrier aircraft and sustained two near misses from 114-kg bombs. Her fire power, however, was not impaired.

At 0940 the *Barham* and *Resolution* closed to 12,436 meters of *Richelieu* and opened fire on the French battleship. The *Richelieu* attempted to return this fire, but the first salvo from Turret II was her last for that day. The guns in the starboard gun chamber failed during the first salvo; the inboard gun exploded, and the outboard gun developed a swelling in the after barrel reinforcement with an 8-meter gash in the rifling. With the main guns now silent, the *Richelieu* carried on the fight with her two 152-mm turrets. Although no hits were made on the *Barham* with these guns, the British battleship was straddled several times by 240-mm shells from the coastal batteries.

Shell damage. On 24 September, during her engagement with the *Barham* and *Resolution*, the *Richelieu* was straddled by several 381-mm shells. Finally, one struck the French battleship between the bridge tower and the mast stack. It caused some minor splinter damage and a small fire which was quickly extinguished, but there were no casualties.

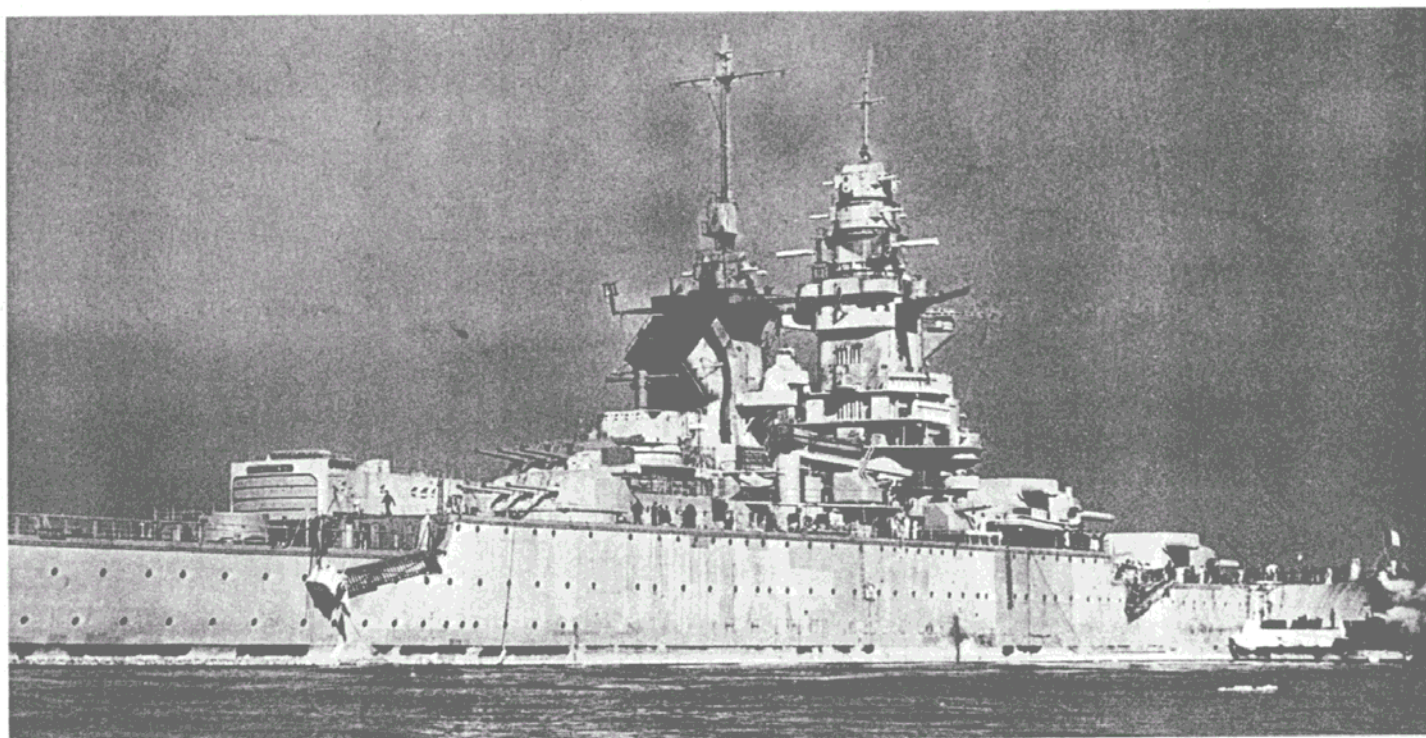
During the night of 24-25 September, Turret I was readied for firing. At 0740 the *Barham* and *Resolution* approached Dakar again. At a range of some 20,000 meters, the *Richelieu* opened fire with Turret I and fired a dozen 380-mm shells. One of these struck the *Barham*'s starboard bulge, abreast of B turret, and opened a hole 1.2 meters in diameter. The British fired about 250 shells at the *Richelieu*, none of which hit the French battleship. After the *Resolution* was hit by a torpedo from a Vichy-French submarine, action was broken off.

Béveziers

An inquiry into the turret explosion concluded that the powder was responsible, but later tests proved it was not at fault. The cause was finally assessed as a defective shell. France was producing 380-mm shells for the first time, and wartime conditions had not allowed adequate testing.

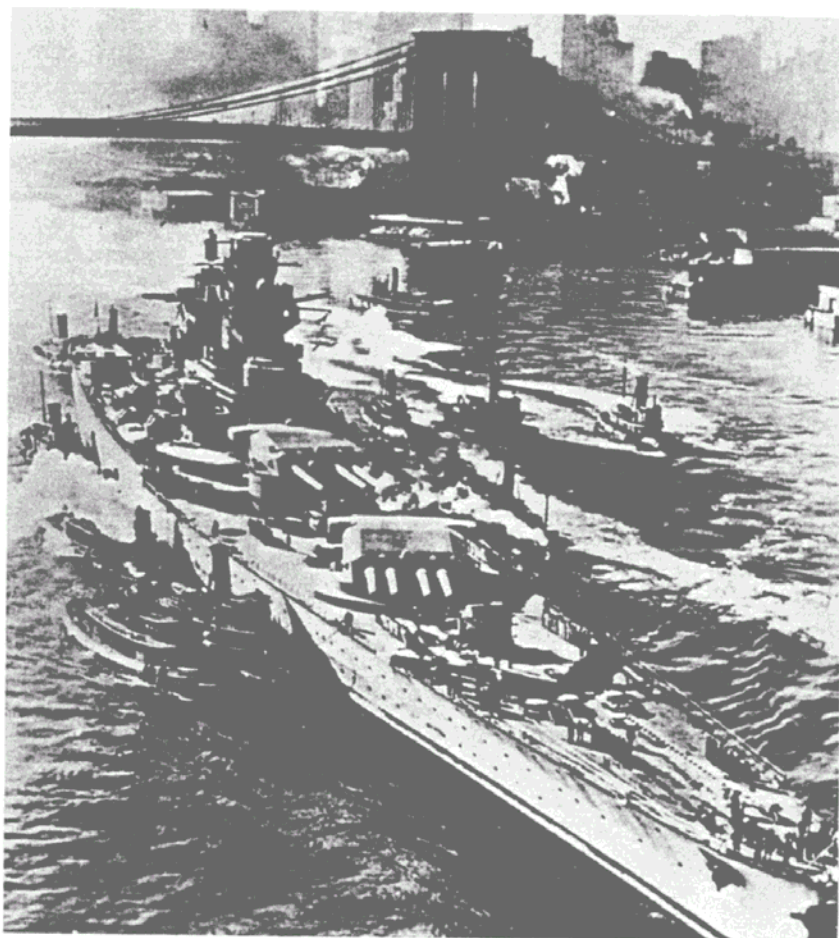
The continued presence of the *Richelieu* at Dakar and the *Jean Bart* at Casablanca created some anxieties in British and American naval circles, since it was believed that these ships might fall into Axis hands. The Vichy government stated that the two battleships would remain in Africa, and there was no intention of permitting French warships to come under the control of the German Navy. During November 1940, President Roosevelt, on behalf of the United States government, offered to buy the two ships. Marshal Pétain repeated that the ships would never be permitted to fall into German hands, and that they could not be sold; their sale would be contrary to the terms of the 1940 Armistice, and in any case the Germans would never permit it. On 23 November 1940, President Roosevelt, after receiving certain assurances from the Vichy French government, informed Prime Minister Churchill that Marshal Pétain would not move the two ships without first informing the United States government.

The *Richelieu* was still at Dakar in November 1942 and took no action against the invasion of North Africa. She was not in condition to steam to the point of action because of the serious damage to the stern and damage sustained to her two guns. Her condition was not known to the Allies at the time. After successful negotiations between Admiral Darlan and the Allies, she came over to the Allied side. On 30 January 1943, with her damaged stern reinforced by a heavy timber cofferdam, the *Richelieu* sailed to the United States for repairs and modernization.



The *Richelieu* arrives in New York on 16 February 1943 for extensive repairs and modernization. A number of original features of the *Richelieu* class shown here were to be replaced, including the hangar, catapult housing, and the topmost rangefinder on the forward command tower, the latter to permit the ship to clear the Brooklyn Bridge and enter the New York Navy Yard. (International News)

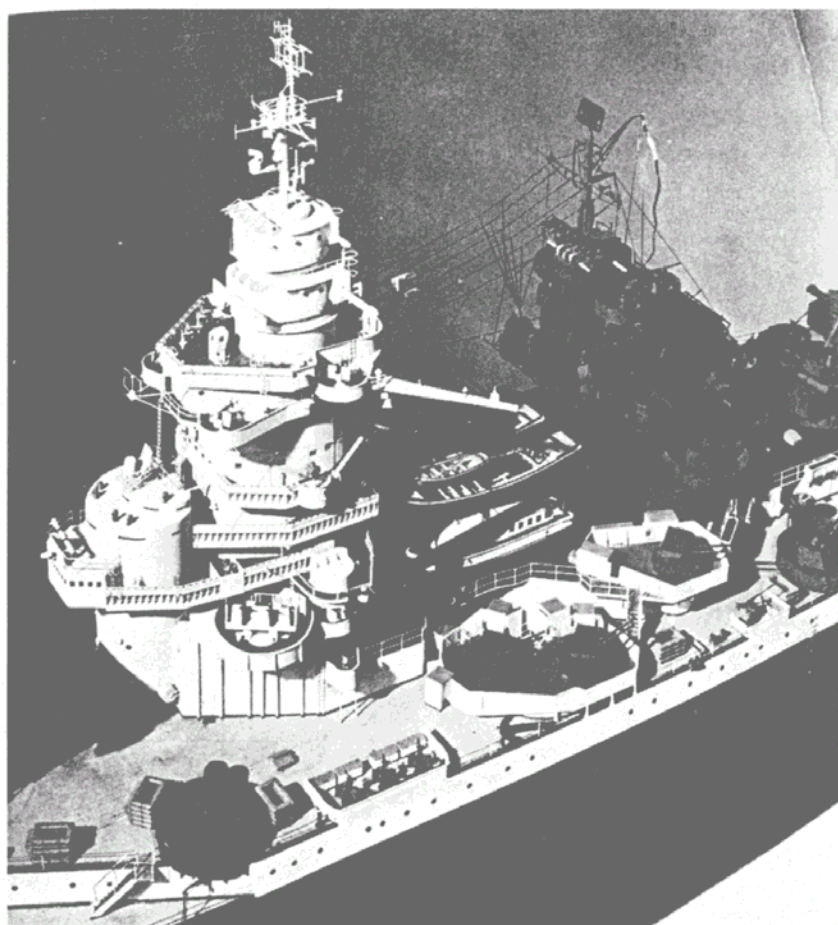
The Richelieu moves up the East River and past the Brooklyn Bridge towards the New York Navy Yard where she will undergo permanent repairs and modernization. Note the missing barrel in Turret II and the topmost rangefinder for the 152 mm forward of Turret I. (Musées de la Marine)



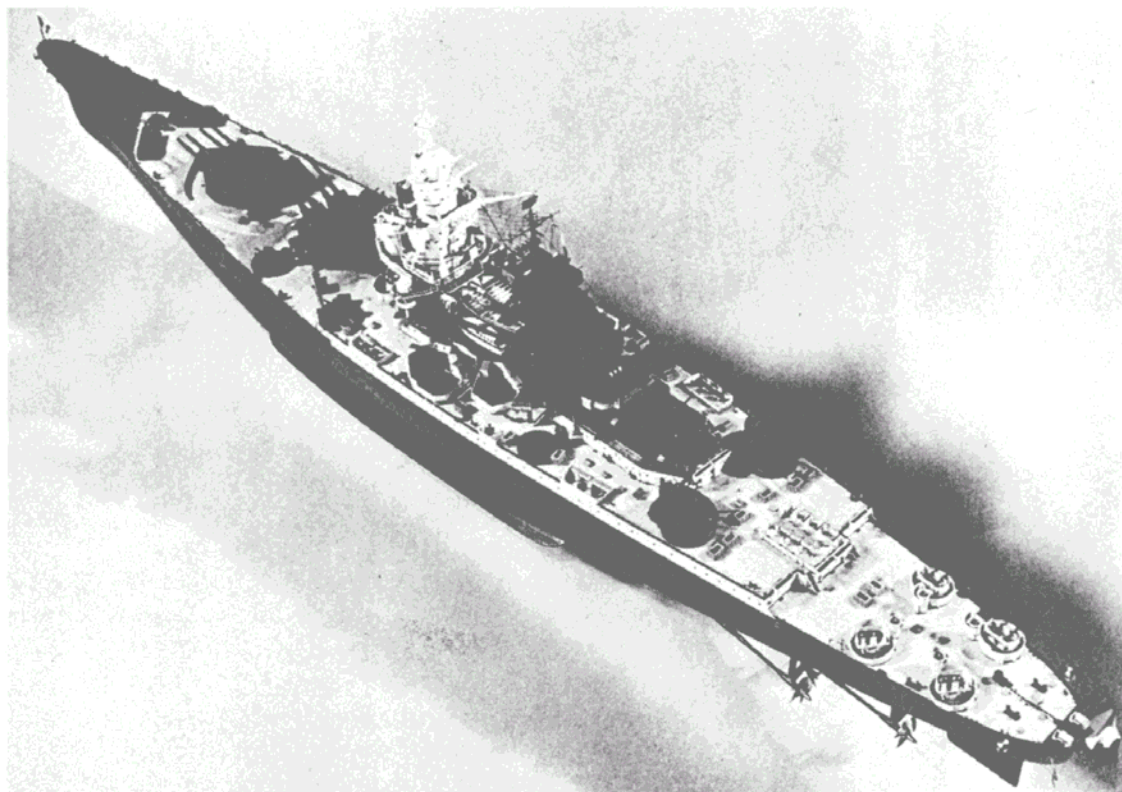
Modernization in the United States. Late in February, the New York Navy Yard began a thorough overhaul and completion of repairs already begun by the French at Dakar, but there were many difficulties. French designs and construction methods differed from those used in the United States. A principal difficulty was the unfamiliarity of American workmen with the metric system of measurement. Plans were also not available, as many were hidden in occupied France or captured by the Germans. French steel alloys were unique, and their specifications were not available. French guns were odd-sized and this would make resupply difficult. The main propulsion plant and the auxiliary machinery were different from American equipment. There were no spare parts; innumerable replacements had to be custom made. In a major alteration, the 380-mm guns were rebored to 381 mm to permit the use of British shells. The two damaged guns in Turret II were replaced by the guns from the *Jean Bart*, which had been severely damaged at Casablanca.

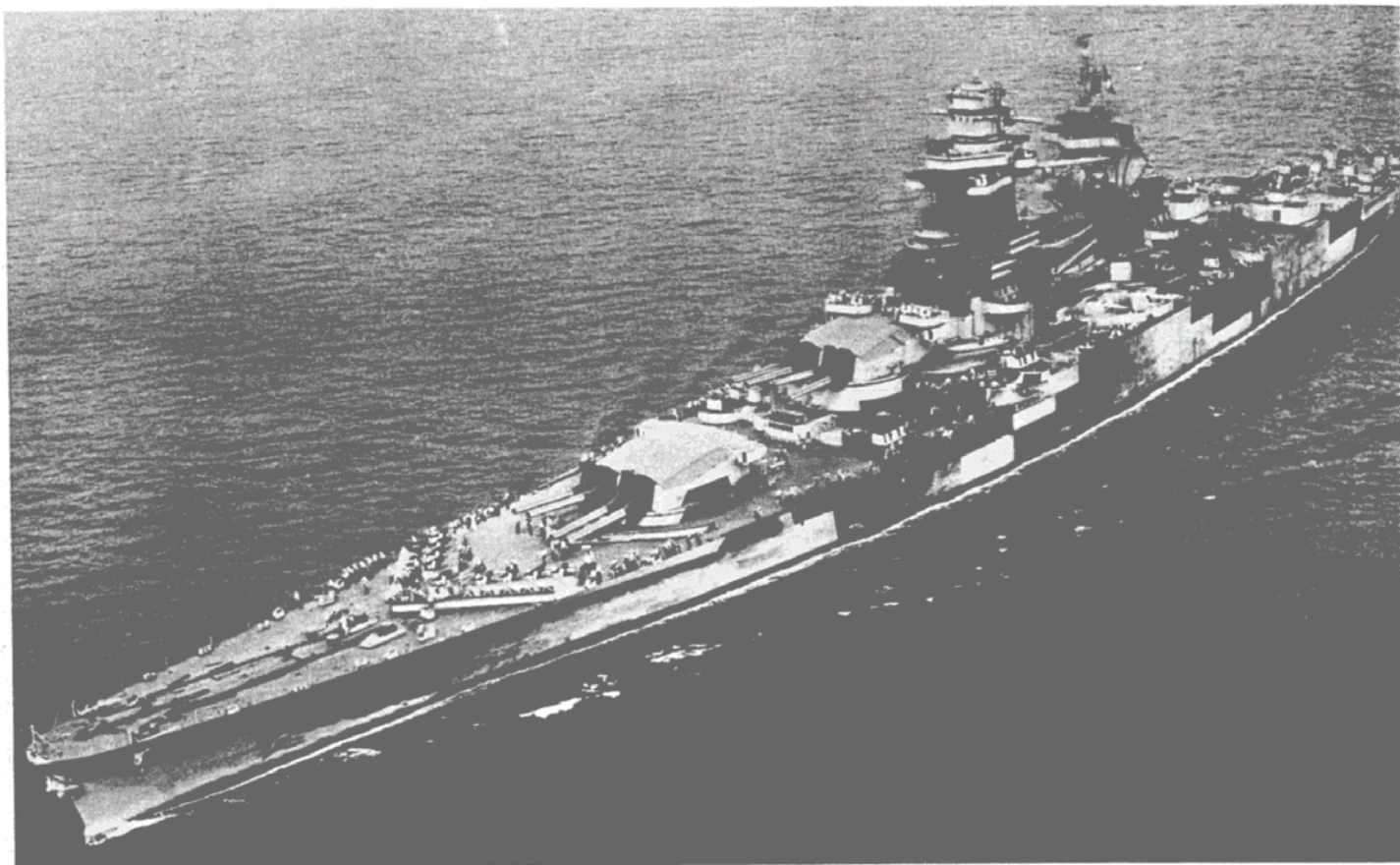
One of the most difficult repairs concerned the damage to the shafts and the realignment of the turbines. The stern tube, at least one section of the line shaft for the inner starboard shaft, and the propeller shafts for both starboard shafts had to be replaced. Workmen unfamiliar with the metric system adjusted the clearances in the turbines. The damaged stern casting was also repaired.

The most noticeable change in the exterior appearance of the ship involved the addition of fifty-six 40-mm machine guns in fourteen quadruple mounts, mostly on the quarterdeck and in the superstructure. Two of these quad mounts were placed at the after end of the roof of Turret II. Fifty 20-mm Oerlikon machine guns were placed wherever deck space was available. For example, eight gun positions were positioned



These two views of a model of the Richelieu show the ship as she was modernized in 1943 with the addition of 20-mm Oerlikons and 40-mm Bofors. The top photo shows the superstructure details. The boat stowage has been confined to an area between the funnel and forward command tower, permitting the placement of 20-mm and 40-mm guns. The lower photo shows the changes made to the after section of the Richelieu. Eight 20-mm guns are emplaced where the hangar used to be, and four quadruple 40-mm Bofors mounts have been placed in the aircraft launching area, permitting a clear field of fire aft for the three triple 152-mm turrets. (Musées de la Marine)

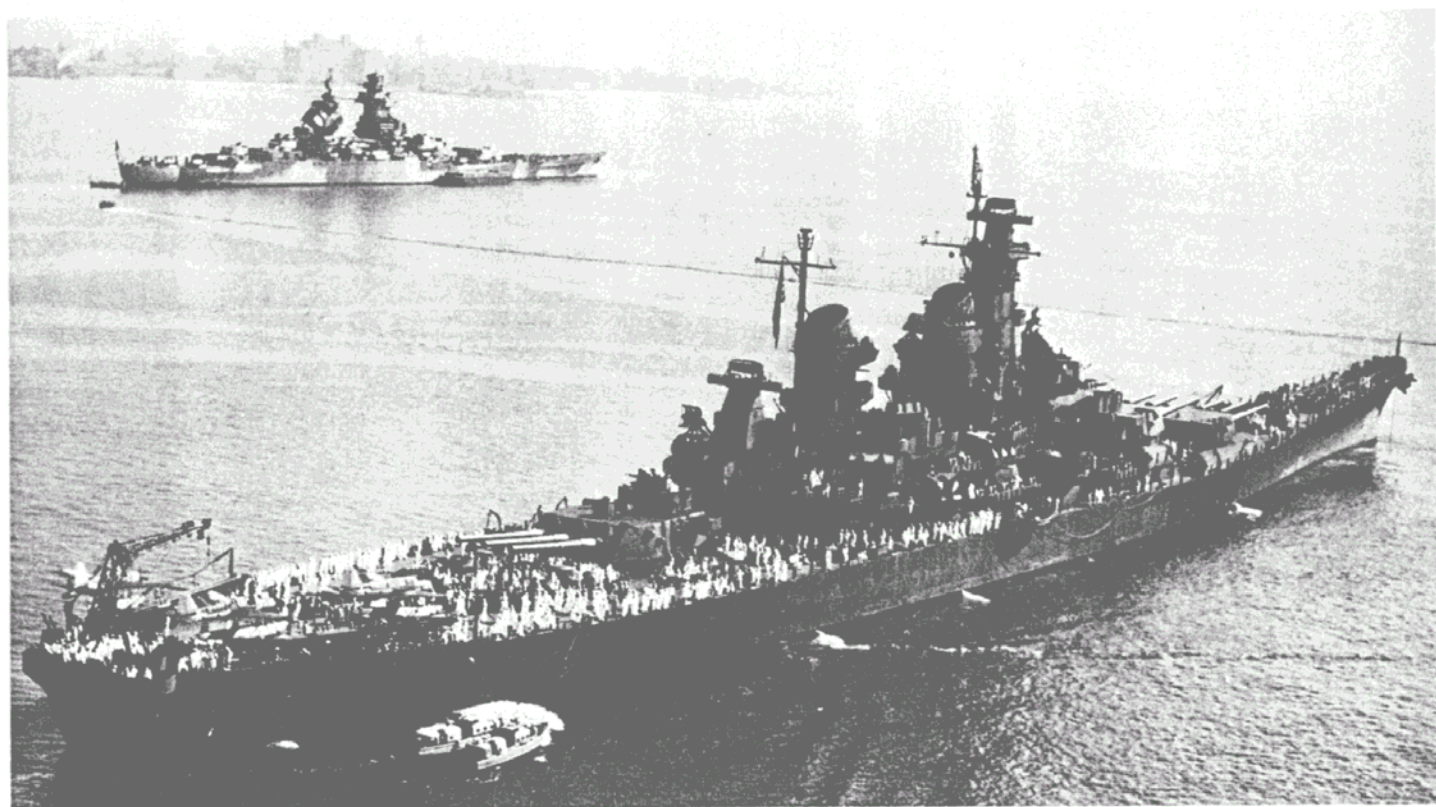




These two photos of the Richelieu in her wartime camouflage were taken while she was undergoing trials and training in Chesapeake Bay in September 1943. The main-battery guns were overhauled and replaced, and all the main-battery guns were rebored to 381 mm to accept British shells of that caliber. Note that the 381-mm guns are mounted on separate sleeves permitting individual firing.

where the hangar had been, and nine others were placed behind the breakwater forward of Turret I. Two guns were located on the centerline 152-mm turret. To accommodate these changes, the boat stowage was reduced and the hangar and catapults removed.

In August 1943 the *Richelieu* was ready for trials and tests. After brief training exercises in the Chesapeake Bay in early September, she sailed in October to Mers el Kébir. She had a brief stay in Africa and then joined the Home Fleet at Scapa Flow in November 1943. During February 1944, the battleship provided cover for a carrier task



The first and the last!!! The battleships New Jersey (foreground) and Richelieu were the only ships of their type to be involved in the communist insurrection in Indochina. The Richelieu was there in late 1945 to early 1946, while the New Jersey's service spanned 1968-1969. The ships are shown here off Old Point Comfort, Virginia, in the fall of 1943.

force in an operation against northern Norway. During her stay in the United Kingdom, eleven single-mounted Bofors were added, increasing her 40-mm battery to sixty-seven guns, and nine Oerlikon single-mount machine guns were removed, leaving only forty-one 20-mm guns.

After her modernization in the United States and subsequent changes in Great Britain to her radar and light antiaircraft armament, the *Richelieu* had much different characteristics than those she had when she left France in 1940. The revised characteristics are tabulated in Table 3-4.

Action against Japan. In March 1944, the *Richelieu* sailed to join the British Eastern Fleet at Trincomalee, Ceylon. Her first action was an assault on Sabang on 19 April by the carriers HMS *Illustrious* and USS *Saratoga* to divert Japanese attention from Allied landings in New Guinea. Several shore-bombardment missions were conducted during 1944 on Japanese positions from Burma to Java. On 7 September the *Richelieu* sailed for France and on 1 October arrived at Toulon to take on new crew members. She sailed to Casablanca where she arrived on 10 October. In January 1945 she was in Gibraltar for a refit and then steamed to Colombo, Ceylon, on 15 March 1945 to join the *Queen Elizabeth* as part of the Third Battle Squadron of the British Eastern Fleet, and conducted gunnery strikes with that ship against Japanese positions in Singapore and the Nicobar Islands.

In May 1945, the *Richelieu*, with some cruisers and destroyers, conducted a search for the Japanese heavy cruiser *Haguro* in the vicinity of the Andaman Islands. The Japanese ship was found by the *Richelieu*'s destroyer screen and sunk by torpedoes.

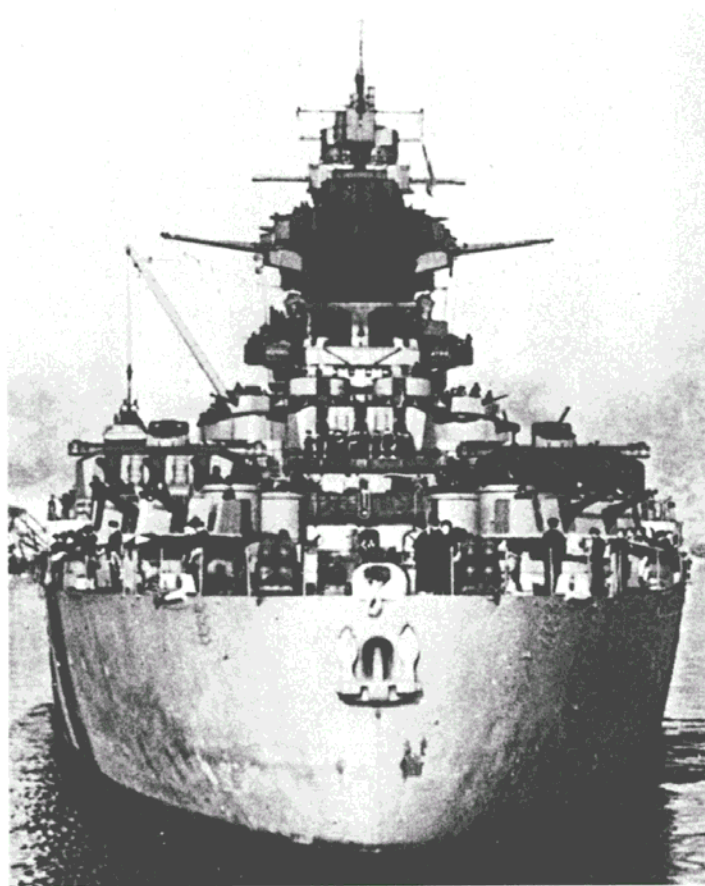
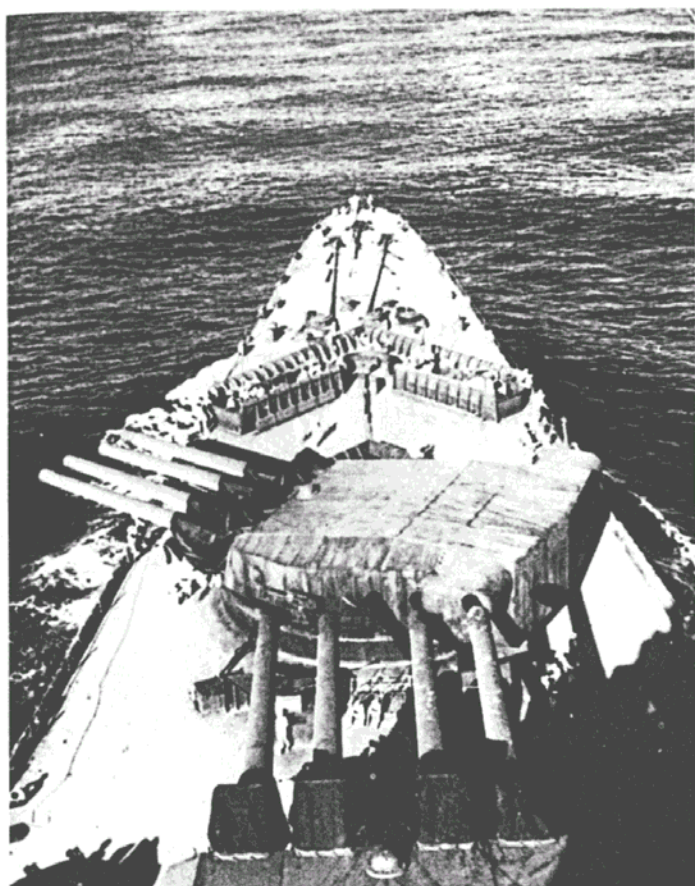
TABLE 3-4

Characteristics of Richelieu after Modernization

Normal displacement (original design)	40,270 tons (40,928 mt)
Normal displacement (after reconstruction)	42,875 tons (43,575 mt)
Full-load (peace time) displacement	47,061 tons (47,830 mt)
Full-load (battle) displacement	47,721 tons (48,500 mt)
Waterline length	794' (242 m)
Waterline beam	108.53' (33.08 m)
Full-load draft (battle)	34.71' (10.58 m)
Full-load draft (peace time)	34.32' (10.46 m)
Normal draft (after reconstruction)	31.79' (9.69 m)
Normal draft (original design)	30.09' (9.17 m)
Armament	eight 15" (381-mm)/45-caliber guns in two quadruple turrets disposed forward nine 6" (152-mm)/55-caliber guns in three triple turrets disposed aft six twin 3.9" (100-mm)/45-caliber guns sixty-seven 40-mm Bofors guns in 14 quadruple and 11 single mounts. By April 1951 the single mounts were reduced to five. forty-one 20-mm Oerlikon machine guns in single mounts (Reduced to 14 guns by April 1951)
Speed	32.6 knots (at overload power)
Shaft horsepower (overload)	177,540 (180,000 mhp)
(normal)	147,950 (150,000 mhp)
Fuel oil (maximum)	6,796 tons (6,907 mt)
(normal operating)	5,872 tons (5,968 mt)
Endurance	10,000 miles at 12 knots 9,500 miles at 15 knots 3,550 miles at 30 knots
Protection	
main side belt	12.99" (330 mm) sloped at 15.5°
deck armor (magazines)	6.69" (170 mm)
(machinery)	5.91" (150 mm)

In July 1945, the French battleship went to Durban, South Africa, for a refit and drydocking. Her captain had declined the opportunity to have the underwater hull cleaned and painted in Trincomalee in a new floating drydock that had arrived recently in this Asian anchorage. He doubted that the dock could adequately support his ship and left the inauguration of the new dock to the British battleship *Valiant*. The drydock broke in two under her 33,000-ton displacement (the *Richelieu* would have displaced 48,500 metric tons in a comparable condition), and for several hours there was great concern that the battleship and dock would capsize. The *Valiant* was refloated, severely damaged, and returned to the United Kingdom. The *Richelieu* returned to Trincomalee on 15 August 1945 when Japan capitulated.

On 5 September 1945, as part of Operation "Zipper," the *Richelieu* left Trincomalee, and early on the morning of 10 September—in company with the HMS *Nelson* which trailed some 900 meters astern—entered the Straits of Malacca. At 0744, four miles from One Fathom Bank, she was shaken by an explosion of a magnetic mine. The noncontact explosion of some 200 kilograms lifted a column of water abreast of Turret I and to starboard, some 17 meters from the side of the ship. Al-



A bow view of the Richelieu taken from the forward command tower after her conversion in the New York Navy Yard. Note the spacing of the 380-mm guns and the anchor arrangement. This stern view of the Richelieu in late 1943 shows the magnitude of the changes made during her stay in the United States. Note the large number of 40-mm guns and how they impact the firing arcs of the 152-mm triple turrets. In addition to three forward anchors, the Richelieu and her sister ships were also equipped with a stern anchor. (Imperial War Museum)



Salvo! The Richelieu fires a broadside at Japanese positions in Port Blair in the Andaman Islands. The French battleship saw extensive service in this theater of war. (Imperial War Museum)



This 1943 photograph was taken shortly after the *Richelieu* joined the Home Fleet. She was on maneuvers with a British cruiser. Wartime censorship eliminated the radar gear on the forward command tower (Imperial War Museum)

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This view of the *Richelieu* was taken in Brest on 16 December 1950 while the battleship was undergoing an extensive overhaul. Note that much of the light antiaircraft battery and electronic gear mounted during World War II still remains.

though the *Richelieu* was violently shaken, there was no serious damage to the hull or framing. The ship was able to maintain her speed, although slightly down by the bow.

The *Nelson* signaled, "Are you gravely damaged?", to which the *Richelieu* responded, "Ready for Action!" A few minutes later, however, the alarm system for flooding sounded, and repair parties found a leak in the compartment where the wine tanks were located. This development prompted a further signal to the *Nelson*, "We have a leak in number 3 compartment. No damage to the hull."

The ships reached Singapore on 11 September. The capitulation of the Japanese garrison there took place on 12 September; the *Richelieu* sailed the same day and arrived at Trincomalee on 16 September. She embarked some troops of the 5th Infantry Regiment and left Trincomalee for Indochina in company with the destroyer *Triomphant* and two British passenger ships. On 3 October she arrived off Cap Saint-Jacques, where the *Richelieu* anchored while the other ships continued up the Mekong River to Saigon. The *Richelieu* stayed off the Indochina coast during most of October and arrived at Singapore on 29 October.

On 17 November the *Richelieu* returned to Indochina and disembarked elements of the 6th Infantry Regiment on 18 November off Nha-Trang. She fired a number of rounds from her 100-mm and 152-mm guns against land targets.

On 29 December the *Richelieu* left Indochina and headed for Singapore, Trincomalee, and the Suez Canal, reaching Toulon on 11 February 1946. She later sailed to Cherbourg for extensive repairs and overhaul in the Homet Drydock.

In August 1946 she concluded maneuvers with some ex-German torpedo boats and the aircraft carrier *Colossus*.

On 15 April 1947, President Vincent Auriol boarded the *Richelieu* for a trip to Dakar. After he disembarked there on 20 April, the ship conducted training exercises with the destroyers *Hoche* and *Desaix* and the carrier *Arromanches*.

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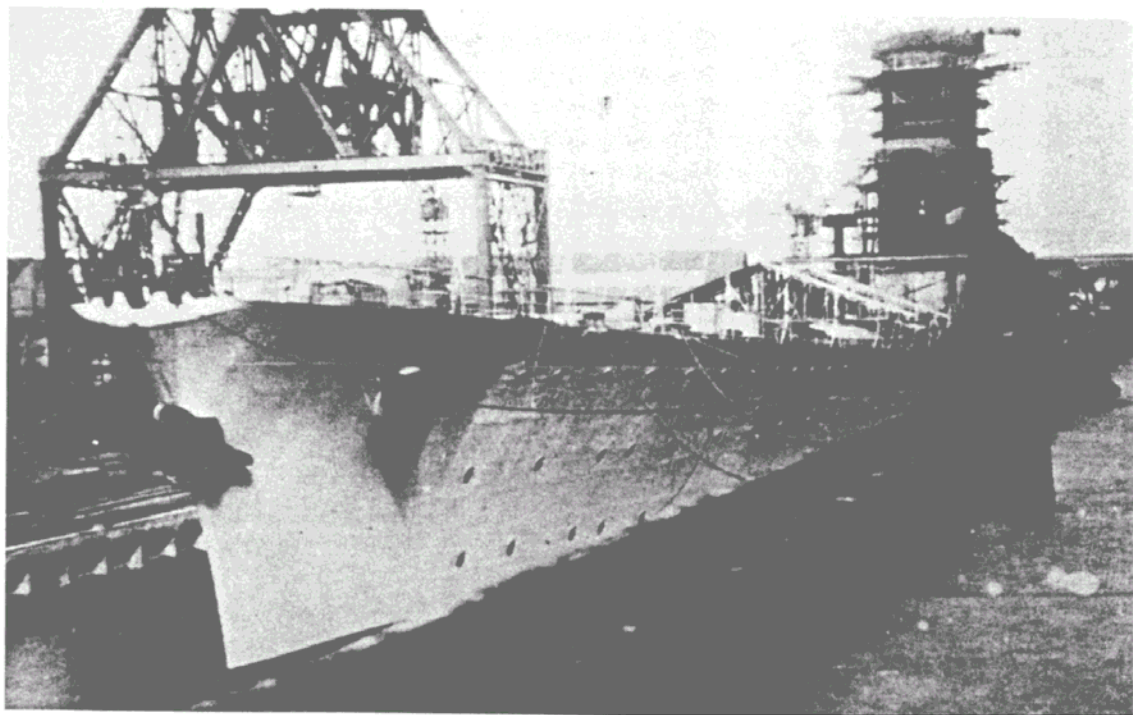
Final Disposition. The *Richelieu* was the flagship of the French Mediterranean Fleet until 1950 when she went to the Brest Navy Yard for an extensive refit. Upon completion of her overhaul, the *Richelieu* took a brief trip to North Africa before being reinstated as the flagship of the French Mediterranean Fleet in Toulon on 1 May 1952. In February 1953 the *Richelieu* took part in NATO fleet exercises with the HMS *Vanguard* and American aircraft carriers. On 21 October 1955 she underwent a brief overhaul in Toulon. Before proceeding to Brest to become a school ship, she went on maneuvers with the *Jean Bart* on 31 January 1956. From 1956 through 1967 she was stationed in Brest. In December 1967 she was stricken from the navy list and sold as scrap for 15,000,000 new francs (\$3,000,000). After being disarmed, the ship was towed out of Brest on 25 August 1968, en route to Genoa to be broken up by Cantieri Navali Santa Maria.

Jean Bart—Operational History. The Construction of the *Jean Bart* was awarded to the St. Nazaire shipyards Chantier de Penhoët and Chantier de Loire on 27 May 1936. Preliminary design was done by the Service Technique Constructions in Paris and the Brest Navy Yard. The Director of Naval Construction at Brest advised the yards concerning final design stages, methods of construction, and the general arrangement of the ship, and several changes were authorized by the French Navy—all of which accelerated construction and improved the outfitting schedule.

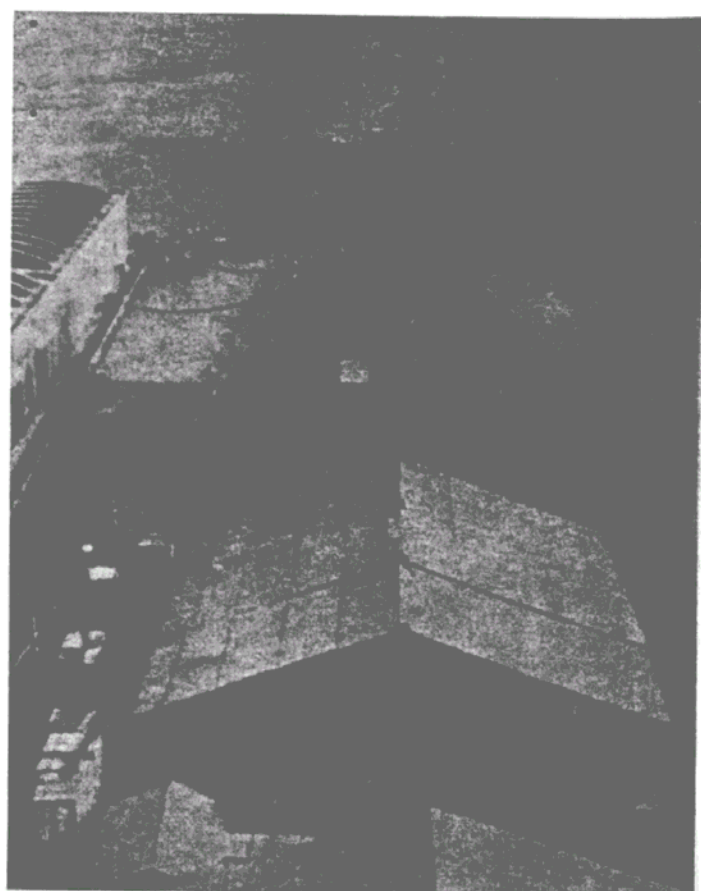
The improvement in the building phase and the use of a new method of construction perfected by the Loire Shipyard reduced the prelaunching period by six to ten months in comparison to that of the *Richelieu*. The Penhoët yard built the forward section of the ship while the Loire yard built the after section. The Loire yard had a new building dock (the "forme Caquot")* which was essentially one drydock in another. While the *Jean Bart* was building in the shallow dock, the deeper dock could have been used to complete or repair another ship. Building the battleship in a drydock was adjudged to be safer and more convenient and eliminated the risk involved in the usual end launch.

The keel was laid on 12 December 1936. Acceptance trials were scheduled for 1 December 1939, but slowdowns in French industries delayed delivery of material. Launching was rescheduled for October 1940, but due to the outbreak of the Second World War, the completion date was advanced three months by mutual agreement of the French and British navies. The work force was increased from 2,500 to 2,800 and the work week was lengthened to seventy-two hours. The ship was floated on 6 March 1940, some seven months ahead of the revised schedule.

* Named for the designer, a prominent French civil engineer: also referred to as "Forme *Jean Bart*."



The Jean Bart is shown after her launch in the "Forme Jean Bart" in March 1940. Work is under way in the superstructure and the main-battery turrets. (Musées de la Marine)



The Jean Bart is in the outfitting basin with her bow pointed towards the Loire River. It is March 1940. By mid-May 1940 a crash program began to complete the ship and dredge a passage to the river channel. On 19 June 1940, the incomplete battleship left her building dock and steamed to Casablanca. (Chantier de l'Atlantique—Penhoët-Loire)

Escape from St. Nazaire. On 10 May 1940 Germany invaded France, and the ship was immediately threatened by possible air attacks. Her only defense was eight 13.2-mm machine guns. Numerous air alerts so delayed construction that the completion date of 1 October could no longer be guaranteed by the shipyards. By 17 May it was decided that the ship had to leave St. Nazaire as quickly as possible, or be destroyed. Departure could not be made until the 20 June high tides, but much depended on whether a 200-meter channel to the Loire River could be properly dredged. On 25 May the situation on the battle front worsened, and the officer in charge of the dredging began cutting a channel to the river without specific orders to do so.

The departure of the ship depended on her completion status. Tugs could move her, but towing a ship of her size at sea while submarines threatened would have been a dangerous and risky procedure. It was concluded on 18 May that the ship would have to move under her own power and that by 20 June there would have to be enough power on two shafts for maneuverability, some means of navigation, most of the electrical power, some internal communications, and radio equipment. To accomplish this objective, the work force was increased to 3,000 men, and then finally to 3,500 men, working on 12-hour shifts. If the schedule could not be met, then the ship had to be destroyed since she was under no circumstances to come under control of the Germans.

The outcome of the race to prevent capture of the ship rested upon an adequate dredged channel to the river. Engineers could only promise a depth of 8.75 meters and a breadth of 52 meters by 20 June, which meant that the passage would be difficult. The ship would have to be in a very light draft condition, nearly empty of water, fuel, and provisions, and could have only one of the main turrets fully completed.

On 22 May the dock was pumped out and the ship's bottom painted. On 3 June the first propeller was mounted on the port inboard shaft, and four days later the starboard inboard propeller was mounted. Both were *Richelieu* spares from the Brest Navy Yard. On 9 June the steering gear and some auxiliaries in the propulsion plant were placed in operation and the galley was completed. Three boilers required to supply steam to two turbines were tested on 12 June. Top priority was given to the construction and installation of the rudders, balancing and alignment of the propellers and shafting, and the installation and testing of equipment within the operational engine room so that the ship would be ready by 17 June.

In the meantime, a decision was made to replace the secondary 152-mm triple turrets—construction of which had been delayed by the lack of material—with five twin mounts of 90-mm antiaircraft guns which were available in the yards. The guns and their magazines were ready for action in record time, but ammunition, shipped from Brest, failed to arrive until after the ship had sailed. There is some question whether all of the ammunition could have been loaded aboard the *Jean Bart*, due to the draft problem in the channel.

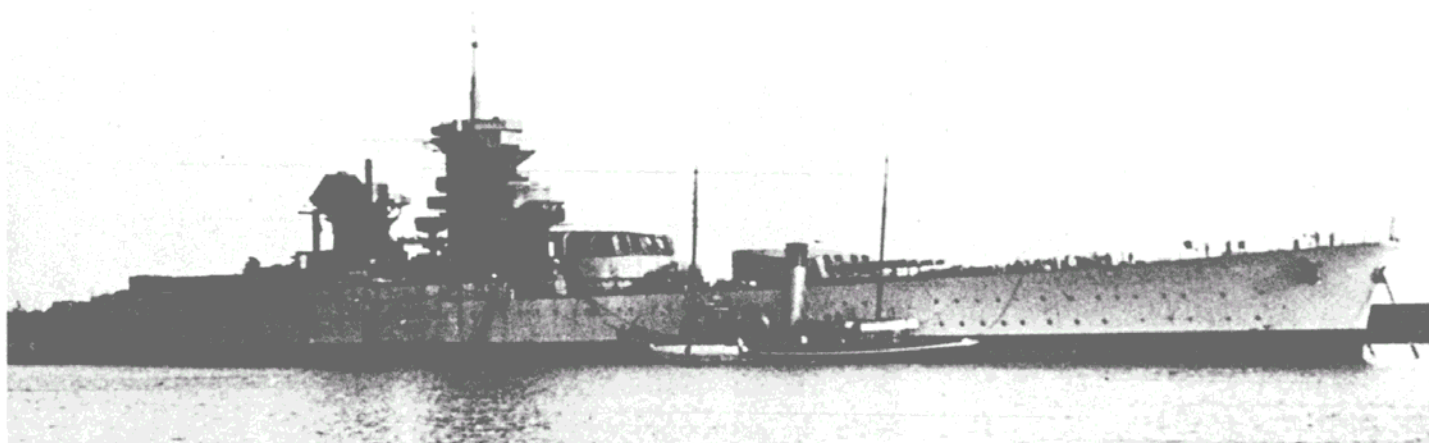
By 10-11 June, the anchor windlasses and capstans were tested. On 13-14 June, the guns and roof of Turret I were fitted. It was decided to complete only the forward turret even though eight 380-mm guns were in the yard; the remaining four would follow in a cargo ship. Turret I guns were installed without the necessary firing equipment, and they were also not properly aligned in their cradles. Great secrecy was attached to this work. Later, when a cargo ship arrived to load the guns and machinery for Turret II, the loading crane failed after two guns had been hoisted aboard the cargo ship. The captain of the *Jean Bart* had refused to take them aboard his battleship because the increased draft might cause her to ground in the narrow channel. The remaining two guns were deliberately sabotaged by shipyard workers. The cargo ship carrying the other two 380-mm guns was sunk by the Luftwaffe.

On 16 June the main turbines, generators, and steering gear were tested satisfactorily, and three boilers in the after fireroom were lighted off. By 18 June the shafts and propellers were connected up, but dockside trials could not be accomplished. A magnetic compass was installed on the navigating bridge, but was not compensated; the engine room telegraphs and some temporary phone connections were installed. Communications were limited to signal flags, two small signal lights, and one 600-watt radio transmitter. Only one of the four 1,500kw turbogenerators was installed, but the two 150kw emergency diesel generators were in place. The main drainage and bilge pumps were not working, but the firemain system was fully operational. Because of the shallow channel, only 125 tons of fuel and an equal amount of feed water was taken on board.

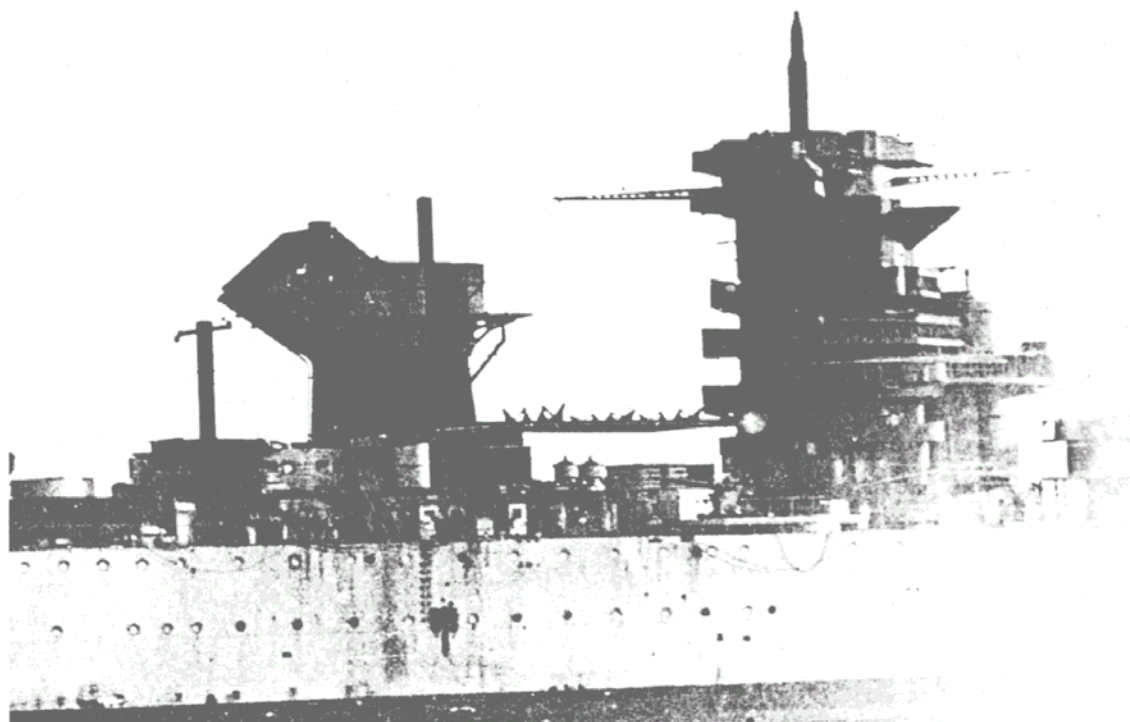
At 1215 on 18 June, while the Germans were entering Nantes only 65 kilometers distant, the French tricolor was hoisted on the *Jean Bart*. During the late afternoon, dockside electrical power was shut off and the ship's only turbogenerator began to supply shipboard power. The circuit breakers had not yet been adjusted, however, and they tripped, cutting off ventilation and lighting in the machinery spaces. Working conditions there became intolerable; it was necessary to start up an emergency diesel generator to supply the necessary power so that work in this space could continue without further delays. Finally, at 0230 on 19 June the generator was operating. Around midnight, a defective fuel-oil transfer-pump motor caused a shutdown of the operational boilers and delayed the correction of a four-degree list. The motor was replaced, the circuit breakers were wedged shut, and at 0300 the boilers were lighted off for a third time.

A successful departure depended on a high tide which would provide necessary clearance in the channel between 0311 and 0445. The calculated clearances were 100 mm at 0321, 200 mm at 0336, and a maximum of 290 mm at 0445. At 2100 on 18 June, the dredging was halted with a channel only 46.5 meters wide. The ship would have very tight clearances in sharp turns and very little water under her keel.

At 0330 on 19 June tugs nudged the battleship out of the drydock, and her bow ran aground in soft mud over a distance of 30 to 41 meters. She was pulled off, but grounded again a half-ship length farther down the channel. The starboard propeller was slightly damaged. The ship was finally freed after 45 minutes, with the aid of additional tugs, and under way at 50 rpm. At 0430 three German planes attacked despite intense light machine-gun fire. The ship was practically motionless; any eva-



The Jean Bart is shown in Casablanca on 24 June 1940, the day after her arrival from St. Nazaire. Note the incomplete condition of the ship, especially the absence of the four 380-mm guns for Turret II.



This is a close-up view of the midship area of Jean Bart on 24 June. Note the single twin 100-mm antiaircraft gun mount which is located just abaft the foremast. Note the missing directors and the incomplete funnel structure.

sive maneuver could have grounded her again. Twelve bombs were dropped; four exploded close aboard and caused no damage, but a fifth pierced the foredeck between the two main turrets. It exploded below deck, pushing the deck upwards around a 200-mm hole and blowing out several adjacent bulkheads. Splinters severed the pipeline to the magazine sprinkling system for Turret I. Small fires broke out, but water from the ruptured pipe quickly extinguished them. At that time the turbines were started and by 0445 the ship was in the middle of the channel making 12 knots.

French fighter planes arrived to provide air cover, but nervous gunners on the *Jean Bart* thought they were Germans and fired on them; one plane was hit, but no lives were lost. With the ship under way, the question was, where would she go? The British offer to complete the ship in a British shipyard had been accepted by the French Admiralty earlier in June; however, it was subsequently decided on 15 June to send the ship to Morocco when the military situation drastically deteriorated. The British were not informed of the change and that same day the Royal Navy sent two seagoing tugs and a destroyer to St. Nazaire to be at the disposal of the captain. They did not learn of the change until the *Jean Bart* reached the harbor entrance where they were waiting to assist her.

Even though the French crew had no experience with refueling at sea, the fleet oilers *Odet* and *Tarn* were waiting at the harbor entrance to supply fuel and fresh water. Two French destroyers, *Le Hardi* and *Mameluke* provided cover. This force steamed at 14 knots until it was beyond the range of the Luftwaffe, whereupon it stopped. It took one hour for the *Tarn* to make the necessary connections; pumping started at 1200 and terminated at 1800 after 1,000 tons of fuel and water were transferred. While refueling, the engine room ventilation system failed, and temperatures there reached 88 degrees centigrade. Men worked in relays to keep the plant operating. Then, a leaky condenser lost vacuum, and steam to the turbines was shut off until the

leak was repaired. By nightfall the ventilation system was again operating, but only under almost unbearable conditions of temperature and humidity.

At sunset, with a U-boat reported in the vicinity, the captain ordered the best possible speed, but shortly after developing full power on the inboard shafts, heavy vibrations and excessive heating in the port low-pressure turbine forced a reduction in speed. Steam leaking from the main condensate system caused difficulty in maintaining a vacuum. The combination of a lack of condensate and the introduction of air damaged the impeller of the turbofeed pump. The difficulty in maintaining a sufficient vacuum caused the starboard condenser to gradually accumulate enough air so that it ejected all of its water into the engine room. It became necessary to regulate the flow of water manually into the system, but at 2130 an air ejector in the starboard turbine exploded. Speed was reduced to 6 knots, not enough to evade torpedoes. At that time, a report was received that a British cargo ship had been torpedoed some distance ahead. A single torpedo hit at this point might have proved to be fatal because of the many holes in bulkheads and decks for electric cables, ventilation ducts, and pipes that had not been sealed. After considerable discussion between the captain and shipyard engineers, it was finally resolved to dismantle an air ejector in the forward fireroom which was not operational and install it in place of the damaged one. The job involved moving parts that weighed as much as 180 kilograms, all by man power, as there was no equipment on board for such work. Several watertight doors and access ladders had to be cut away in the process. In the meantime, adjustments were made in the settings and connections for the steam piping and electrical systems. By 1400 on 20 June the ship was making 14 knots again. She had steamed 170 miles from St. Nazaire at an average speed of 7 knots and was still 800 miles from Casablanca.

Full power was regained on the inboard shafts by noon of 21 June. The only concern then was the loss of feed water. The forced combustion boilers could only use distilled water, a limited amount of which had been supplied by the *Tarn*. Part of that had been lost in the ventilation system and more of it in the main steamline leaks. There were no evaporators in operation, but the necessary water was finally distilled in an auxiliary boiler.

The gyrocompass was placed in operation on 22 June, but navigation was still handled on board the *Le Hardi*. Despite operating with a crew that was 50 percent sailors and 50 percent shipyard workers, the ship arrived safely in Casablanca at 1700 on 22 June 1940. After the steam ejector was repaired and feed water supplied, she had averaged almost 21 knots.

Some civilian technicians chose to remain in Casablanca, but there were no installations or facilities that would allow outfitting to continue, and most work was halted. Besides, much equipment had been left in St. Nazaire, which came under control of the German Navy after the 1940 Armistice.

Later in 1940, some work was resumed on the *Jean Bart*, including adjustments and the installation of the firing mechanisms of Turret I.

By May 1942 the final mounting and adjustments to the loading and firing mechanism of Turret I were completed. Turret II remained incomplete, but its cupola was loaded with cement blocks to increase the draft and decrease the stern trim. All this work was accomplished under extreme secrecy by the ship's crew under the Director of Heavy Artillery—Naval. It was necessary to conduct gunnery trials with Turret I, since the mishap experienced by the *Richelieu* at Dakar was not to be repeated. Under the terms of the 1940 Armistice, the German and Italian representatives in Casablanca were consulted about the gunnery trials, since the Armistice expressly forbade any improvement in existing military equipment under Vichy control. After much discussion, the trials were finally approved just as long as the *Jean Bart* remained in

harbor. On 19 May 1942 the four 380-mm guns of Turret I fired five salvos seaward. The main armament of the *Jean Bart* was ready for action! The American consul in Casablanca reported this development; this certainly was to figure in Anglo-American invasion plans of North Africa in November 1942.

The 152-mm armament could not be completed in Casablanca under the terms of the Armistice. Not only were there no guns or turrets, but there was no 152-mm ammunition in North Africa. There was a limited supply of 90-mm ammunition, however, so that the 90-mm makeshift battery installed in St. Nazaire was retained.

There was some addition to the light antiaircraft armament, and by 8 November the ship had on board five 37-mm guns in one single and two twin mounts, ten 13.2 single-mounted machine guns, four Browning machine guns, and four 13.2 twin-mounted Hotchkiss machine guns.

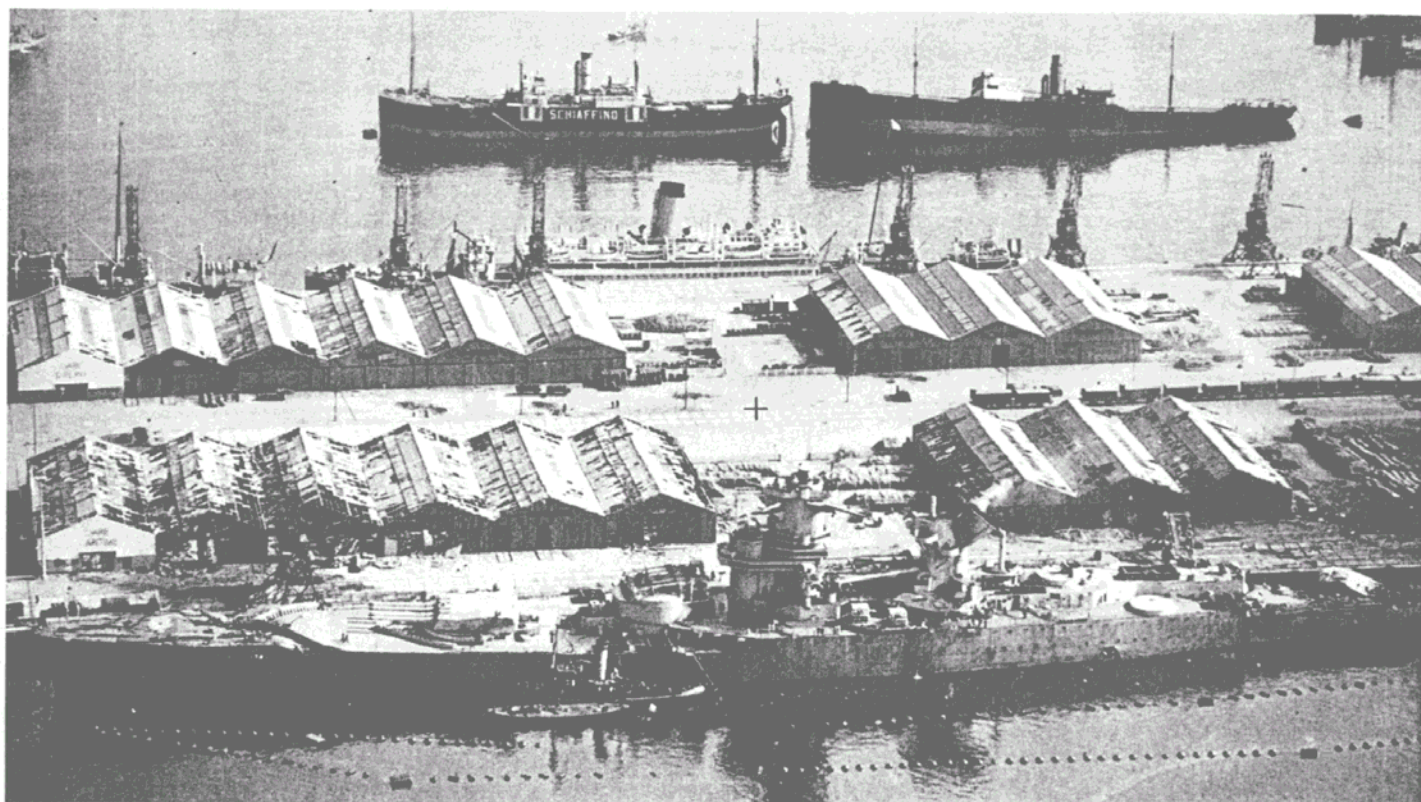
The crew of 700 men worked only on equipment maintenance, as the ship was prohibited from leaving Casablanca. The damage from the bomb hit at St. Nazaire was difficult to repair, because special alloy steels of the type used in the *Jean Bart* were not available; the hole was simply patched with mild-steel plates.

Naval battle of Casablanca. Although the ship was only partially completed, the single operational main turret played an important part in the defense of Casablanca by the Vichy-French forces during the Allied invasion of North Africa in November 1942. Prior to that time, the only action by the ship against Allied forces consisted of firing at British reconnaissance planes that flew over Casablanca once a month; on 31 July 1942 she shot one of them down.

The landing beaches for the American forces in Operation Torch were northeast of Casablanca and within range of the *Jean Bart*'s 380-mm guns, which served as a formidable shore battery. The neutralization of these and other guns was a major American objective.

The *Jean Bart* was moored at the Delandé Dock. Early on 8 November there were reports of warship movements offshore, and at 0500 the crew went to battle stations. At 0640 the main-battery guns were loaded. Ten minutes later two cruisers were spotted, although visibility was poor from the battleship due to the smoke of French destroyers lighting off in the harbor. About ten miles offshore, there was a U.S. task force consisting of the new battleship *Massachusetts*, the heavy cruisers *Wichita* and *Tuscaloosa*, and four destroyers. Around 0700 Batterie El Hank (a group of four 194-mm and four 138-mm guns about two miles from the *Jean Bart*) opened fire on the U.S. ships. They in turn fired on the *Jean Bart*. A few minutes later the *Massachusetts* opened fire with her 406-mm guns after being missed by five 194-mm shells from El Hank. At 0708 the *Jean Bart* fired two shells at a cruiser at a range of 22,000 meters. Smoke prevented accurate spotting, and she had no fire-control radar, only surface- and air-search equipment. She fired four salvos but ceased fire at 0719, because the target was further obscured by a smokescreen laid down by French destroyers to cover their departure from the harbor.

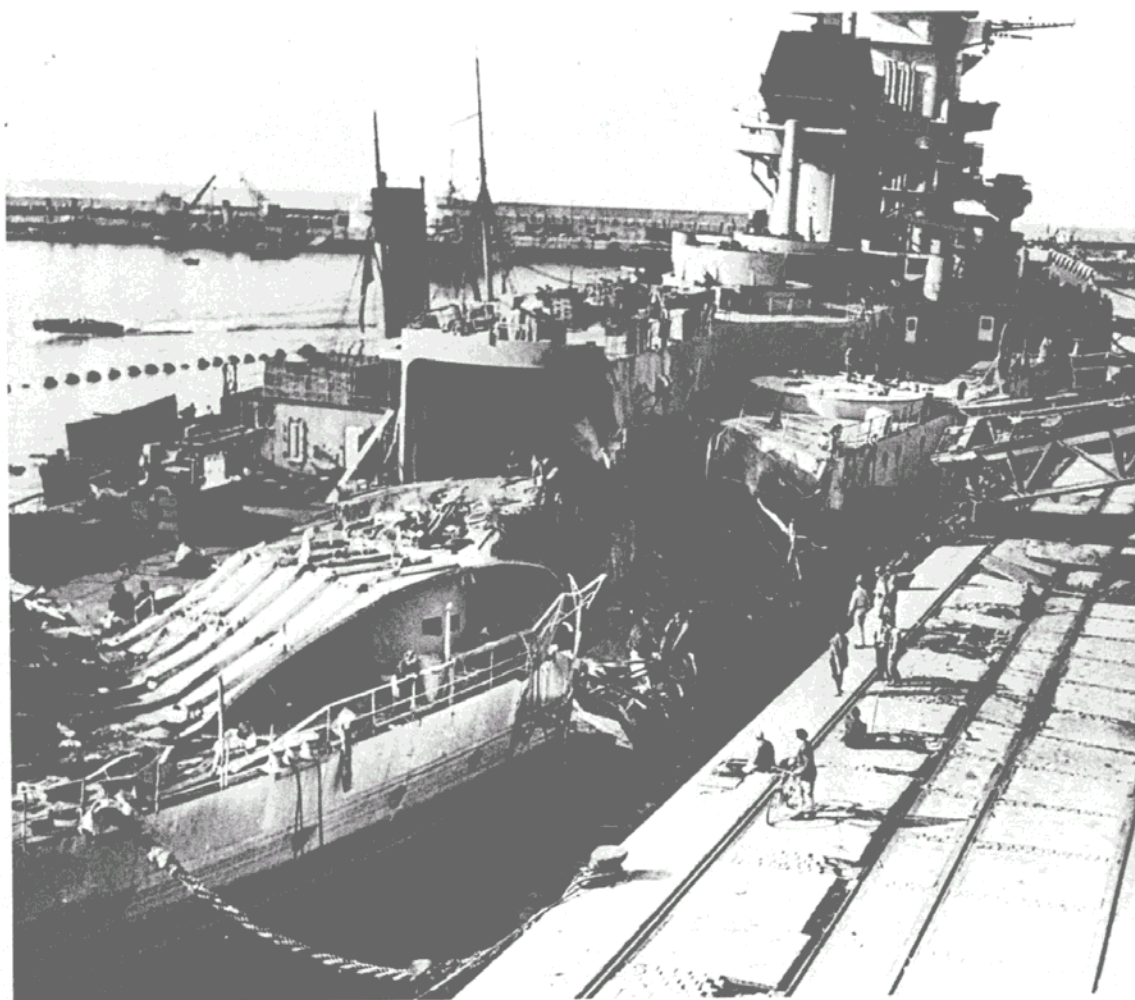
Before the gun battle commenced, the U.S. carrier *Ranger*, some 30 miles northwest of Casablanca, launched nine Dauntless dive-bombers which later reported that the *Jean Bart* was firing on American planes. Actually, her targets were ships offshore. Between 0713-0718 the planes attacked with 227-kilogram bombs. One struck near the shaft of the port catapult, holed the deck, and passed through several decks. A resulting small fire was quickly extinguished. The bomb passed through the shell plating and caused some flooding in the hand-steering compartment in main watertight compartment R. Another bomb hit on the quay alongside compartment M, collapsing part of a bridge crane. The bomb's explosion hurled rocks against the



An aerial view shows the damaged Jean Bart in November 1942 after the naval battle at Casablanca. Note the incomplete main-battery turret and the damage to the bow and stern areas, as well as the sunken merchant ship in the background, victim of American bomb and shell hits. The hole in the side shell just above the waterline on the portside aft is from a 406-mm shell fired by the USS Massachusetts. Also note the torpedo nets arrayed around the Jean Bart and the heavy damage to the Delalande Quay.



This close-up of the Jean Bart's bow after the naval battle of Casablanca shows the heavy damage sustained in the anchor windlass compartment from a 454-kilogram bomb hit.



A starboard-quarter view of the Jean Bart in November 1942 shows a close-up of the heavy damage sustained from a 454-kilogram high-explosive bomb and the resultant fire. Note the damage to the quay from bomb and shell hits.

starboard side of the ship, and these dented or gashed the shell plating. In the meantime, shells from the U.S. warships offshore fell short and exploded on either side of a jetty some distance forward of the *Jean Bart*.

The *Massachusetts* had opened fire at 0704; at 0740 she commenced to change course. The ship ceased fire at 0833, with a seven-minute break in her main-battery fire. The initial range was 22,000 meters. Nine full salvos of nine shells each and thirty-eight salvos of either three or six shells were fired at the *Jean Bart* or Batterie El Hank, with the former taking five direct hits between 0725 and 0810.

The first shell hit on the starboard side aft over the admiral's cabin and went through two light decks (one covered with wood), the 150-mm armored deck, the lower 40-mm armored deck, and the light 7-mm first platform (2^e Faux Pont) before exploding in the aftermost magazine for the 152-mm wing turrets. A shell fragment deflected by the 233-mm after armored bulkhead passed through a light bulkhead, which divided the magazines of the center and wing turrets, and the main transverse bulkhead between compartments O and N, forward of the point of entry. The base plate came to rest in the turbogenerator compartment (the after electrical station) in compartment O. (See figure 3-2.) No ammunition was stored in either magazine, as the 152-mm turrets had not been installed.

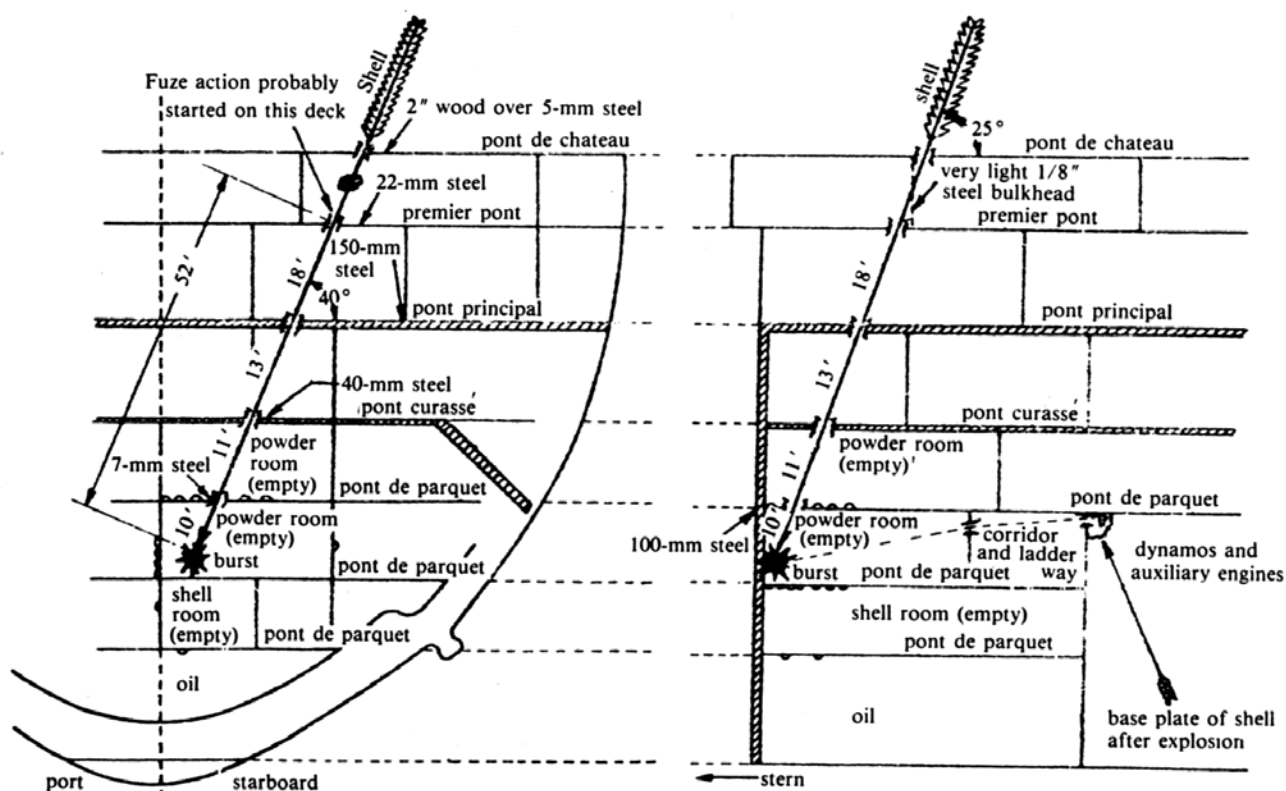


Figure 3-2. First shell hits on Jean Bart.

At 0735 a salvo fell short of the bow to port, and some holes were torn in the light plating around the waterline in two forward watertight compartments; minor flooding occurred.

A minute later a salvo of 406-mm shells struck the dock. Stones were hurled against the starboard 90-mm gun positions, and small leaks developed in compartments B and C. At 0737 another shell struck the light plating of the starboard afterside of the main funnel, tearing away some of the plating, piercing two light decks and a light bulkhead, and passing out through 13-mm shell plating just above the 150-mm main armored deck. The plating was thick enough to initiate fuze action, but the fuze delay of 0.035 seconds would have detonated the shell below the surface of the water. Whether the shell exploded or not is not known, but there was a large hole in the side shell just above the armored deck abreast of the centerline 152-mm turret position. The top of the armor belt and the armored deck was gouged at the point of exit of the shell.

The *Massachusetts* resumed fire at 0747, but her initial fire was inaccurate. It was not until 0804 that a salvo fell close to the *Jean Bart*; this time 406-mm shells fell 50 meters to port. She received some more heavy damage, however, commencing with two hits at 0806. One hit on Turret I ricocheted against the port edge of the horizontal 150-mm armor at the top of the barbette and went into the city of Casablanca. It was later recovered as a war souvenir by the French. The projectile lost its base plug, fuze, and filler—probably on first impact. A large piece of the 150-mm cap plate on the barbette was gouged up and jammed the turret in train. As this main-battery turret was the only one operational, the turret could not fire at moving targets for several hours. A private contractor had to cut away torn cemented armor with torches before

the turret resumed normal operations at 1724. A 90-mm gun mount on the port side of the turret was completely carried away.

The second shell in that salvo ricocheted off the starboard side of Turret II's barbette at a very oblique angle, which caused the loss of the projectile's base plug, fuze, and filler. It thus became an inert missile, but penetrated two decks and was deflected aft, after striking the main armored deck. It glanced off that deck, penetrated several bulkheads, and passed through a petty officer berthing space and into a petty officer lounge (cantine). It came to rest near the ship's centerline adjacent to the communication tube to the conning tower. The executive officer was hit and killed by the projectile, which caused only slight damage to the ship. This shell also became a war souvenir in the French Admiralty Building in Casablanca.

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At 0810 the fifth and last shell hit the quarterdeck, two meters forward of the starboard catapult. (See figure 3-3.) It went through the 16-mm main deck at an angle of 25 degrees to the decks and burrowed its way towards the ship's centerline, down through several decks before penetrating the 100-mm armor shelf (located between the after armored bulkhead and the steering-gear room) and exploding in a ballast tank in compartment R. The after control station was completely wrecked and the hand steering-gear compartment further damaged. Fuze action probably started on the penetration of the quarterdeck. A fragment of the shell's nose left the ship through the port side near the keel and made a hole in the port ballast-tank plating. This caused the flooding of this compartment. Water also entered the main steering space aft of the port ballast tank and the hand steering room.

A number of 406-mm shells that missed the *Jean Bart* hit the dock and nearby merchant ships, sinking two of them. A third ship was set on fire by 203-mm shells from the heavy cruiser *Tuscaloosa*.

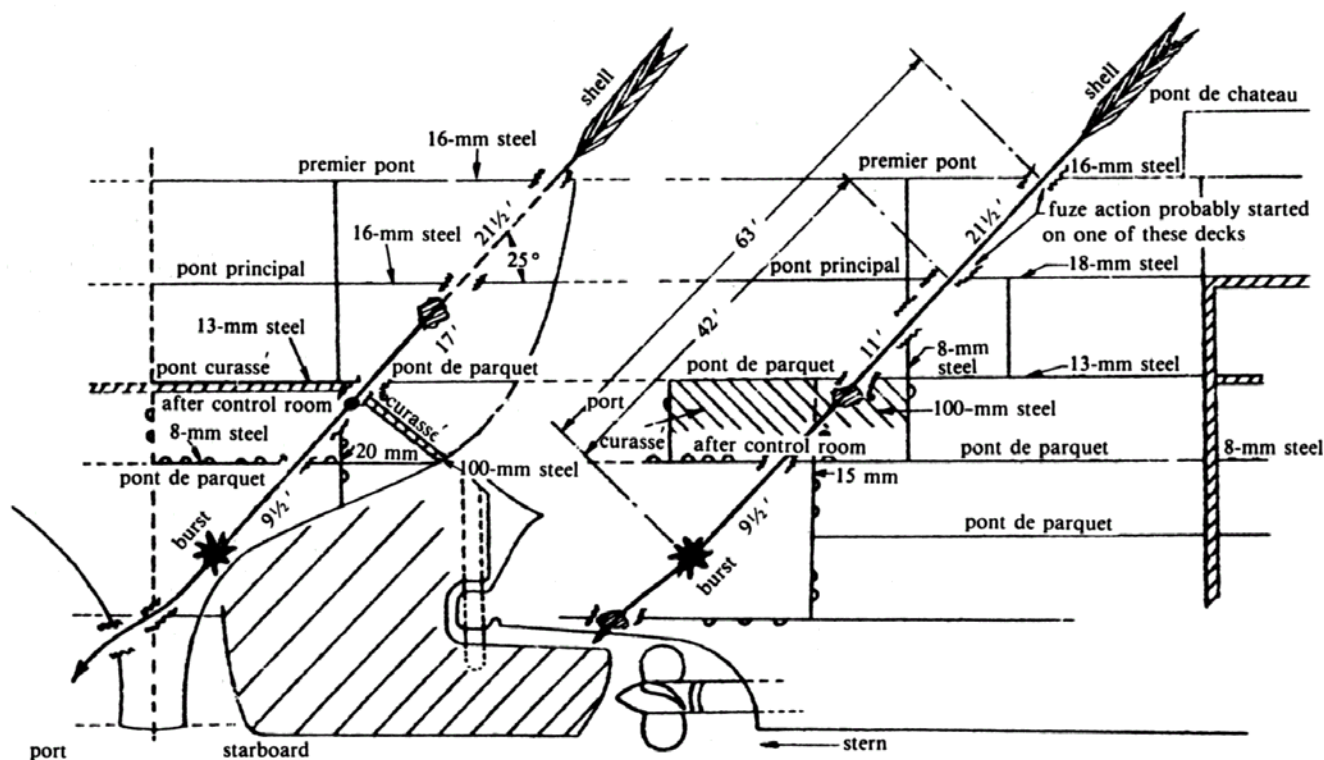


Figure 3-3. Fifth shell hit on *Jean Bart*.

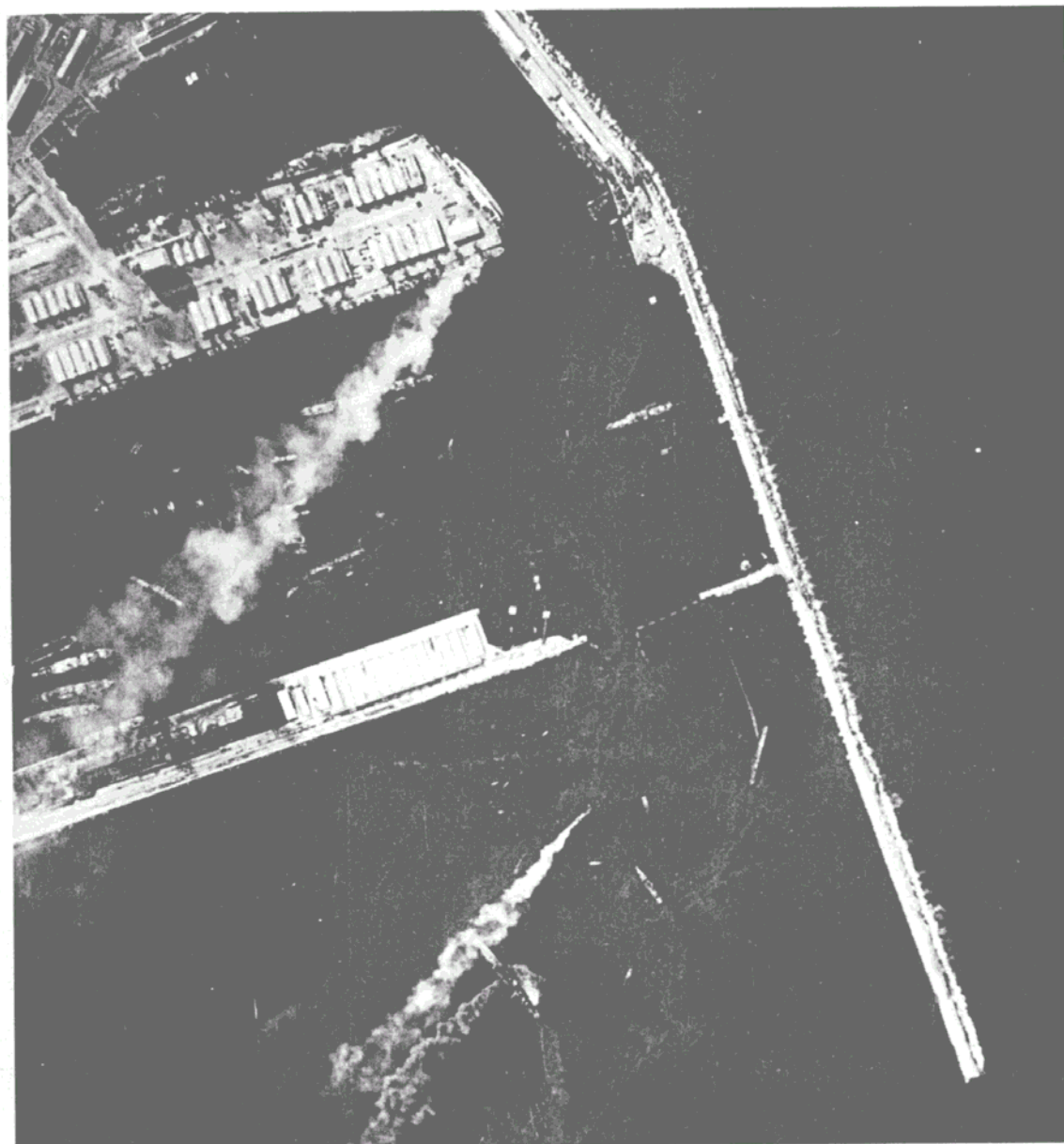
Bomb damage. During 9-10 November U.S. troops advanced slowly along the Fedhala Road towards Casablanca, despite strong resistance by French forces and their heavy artillery fire, which was supplemented by guns of the shore batteries. During the afternoon of 9 November, the *Jean Bart* fired some two hundred and fifty 90-mm rounds at coastal targets. Around 1100 on 10 November the French sloops *Commandant Delage* and *La Gracieuse* shelled the terrain ahead of the American infantry. The American Command thought that these ships were the vanguard of a more powerful force and despatched the heavy cruiser *Augusta* and four destroyers to fire on them. The *Augusta* closed to 18,300 meters and opened fire at 1139. The U.S. ships had closed to 16,200 meters from the *Jean Bart* when she surprised them by opening fire at 1141 (1241 local time). It had been assumed that her main guns had been silenced by the *Massachusetts* two days earlier.

The *Jean Bart* fired nine two-gun salvos in ten minutes. The last three straddled the *Augusta* and splashes deluged her bridge and lookout positions. The *Augusta* fired several salvos at the *Jean Bart*, but changed course around 1145 and quickly left the area. The *Jean Bart*'s third salvo had caused the French to make an incorrect adjustment in their fire; one shell barely missed while the other dropped a considerable distance away. The next salvo, adjusted accordingly, missed and the *Augusta* was able to make her escape unscathed. The third salvo was so erratic because one of the shells pierced the jib of a crane on the quay, which diverted it from its true trajectory.

The *Jean Bart* was to pay heavily for this shelling of the *Augusta*. At 1458 on 10 November, nine aircraft from the *Ranger* attacked the French battleship with 227-kilogram bombs. Two hit the ship, and another struck an oil barge moored abreast of Turret I to port. One bomb hit the starboard shell plating near its juncture with the forecastle deck. The bomb immediately exploded within the compartment. The starboard shell plating between the main and forecastle deck was curled away from the ship, leaving a large hole approximately 5 meters deep and 20 meters in length. The forecastle deck in way of the explosion was bulged up and torn. The port shell plating and the forecastle deck were also pulled apart at their juncture. The bulging of the deck also caused the distortion of the forward breakwater, and the starboard section parted at a riveted joint. The anchor windlass and crew living spaces were totally destroyed. A small fire in compartment D was extinguished after the attack ended.

The second bomb struck an area already devastated by a previous bomb and a 406-mm shell hit. Its explosion on the starboard side of the quarterdeck forward of the catapult in compartment Q demolished a 30-meter-long section of the main deck on the starboard side from the after termination of the superstructure to the starboard catapult turntable housing. The side shell between the main deck and the armor deck in section Q was completely obliterated, and a section of the main deck was thrust back over the catapult turntable housing by the tremendous blast of the explosion. A serious fire that broke out in this area finally entered the after electrical plant. It was brought under control after five hours with the aid of fire and salvage tugs and civilian firemen. Much of the firefighting water poured down holes in the deck caused by bomb or shell fragments, as well as through access trunks into compartments below the waterline, filling the ship with some 1,000 tons of water. The after turbogenerator room was partially flooded, and the engine rooms had to be evacuated because of the smoke which had entered through the ventilation trunks and air intakes.

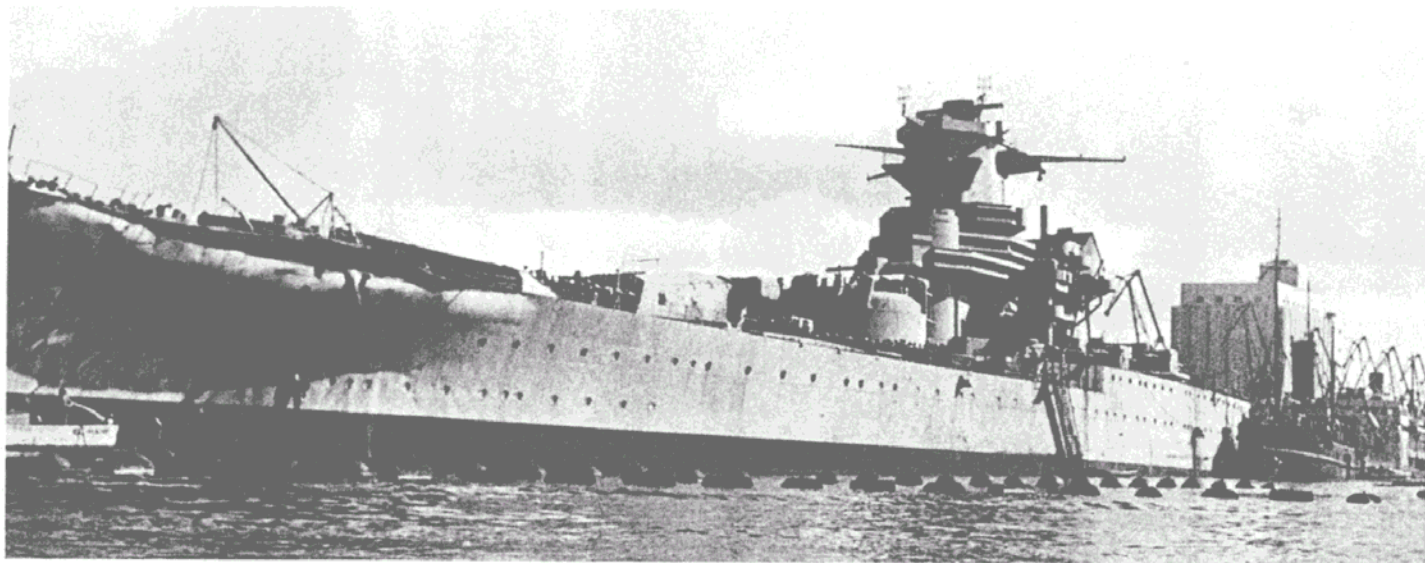
Total damage, including the effects of bombs and shells, produced varying degrees of flooding in the engine rooms, after turbogenerator room, the 152-mm magazines, the after control station, number 2 heating main, and the after trim tanks. One bow trim tank took some water, as bomb fragments had passed through the splinter deck and bottom plating. There were leaks in the starboard cable tunnel. Because much of the pumping system was not yet in operation, the leaks could not be stopped, and



This aerial view of the eastern sector of Casablanca harbor shows the Delande Dock during the afternoon of 8 or 9 November 1942. The Jean Bart can be seen at the upper left with double torpedo nets arrayed around her port side. This photo also shows the damage to the dock and ships in the harbor from the naval gun battle of 8 November. The passenger steamer Porthos, hit by 203-mm and 406-mm shellfire, has capsized against the end of the dock.

water progressively flooded after compartments as far forward as the after engine room, which was half filled. The flooding eventually led to the grounding of the ship by the stern. The cast-steel connection of the stern frame to the hull was somewhat weakened by the fragmentation damage from the explosion of a 406-mm shell, and it ruptured shortly after the grounding occurred.

There was serious flooding in the after turbogenerator room and the turbogenerators in the forward engine room were not in operation, so that emergency electrical power had to be provided by the diesel generators in the generator room located between the two main turrets. This development impaired the fighting ability of the ship, since the full use of the emergency diesel generators was needed to develop



These two low-level views show the extent of bow damage sustained by the Jean Bart from a 454-kilogram bomb hit. In the upper photo, the remains of the anchor windlass space can be seen. A fire broke out and caused the buckling of the plating and the peeling of paint. Note also the perfect tear along the riveted seam just above the deck. The lower photo shows the port side where the bomb's explosion caused the outward bulging of the side plating. This caused the failure of the deck edge seam with the side shell.



the requisite 460-volt power for the operation of the turret. It was decided to use the 230-volt power from these generators, so that the 90-mm guns could remain in action and the normal shipboard current could be maintained. The hull plating, decks, and a portion of the superstructure were damaged, but in compartments D, E, Q, and P the damage to hull structure was critical.

Even though the *Jean Bart* was seriously damaged, the engagement did not provide a good basis for the constructive criticism of any design deficiencies, with the exception of the use of 150-mm deck protection over the 152-mm cartridge magazines. The protection provided simply failed to stop a 2,700-pound armor-piercing 406-mm shell. The ship could not be completed in Casablanca, she was not fully manned, she had a makeshift armament with only one operational turret, and she had no fire-control equipment. Many of her crew were apprentices, as she was serving as a school ship in 1942. More importantly, the *Jean Bart* was moored to a quay and incapable of maneuvering—an easy target for bombs and shells. She had only four 380-mm guns, a jury-rigged fire-control system, and as a result, could only fire two-gun salvos for

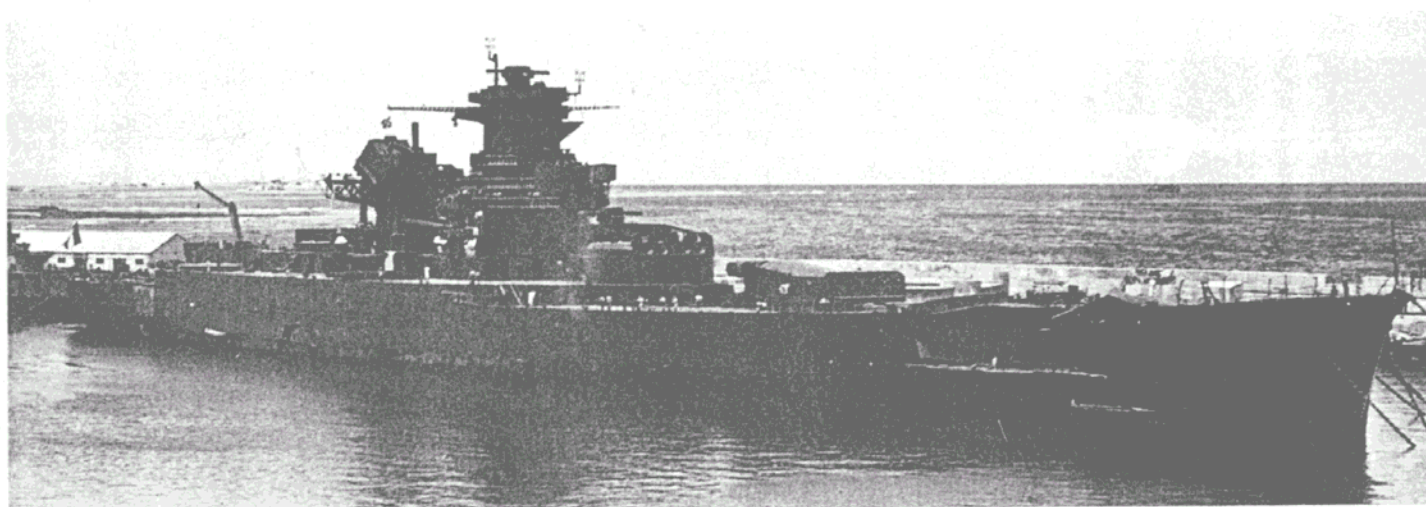
ranging before her intended target could be brought under effective fire. Lacking her entire secondary armament and much of her antiaircraft battery, the ship could not provide a protective volume of fire.

Conversion proposals. The ship was later refloated and, in hopes of sending her to the United States for completion, given makeshift repairs. She was destined to remain at Casablanca for most of the war, because her completion as a battleship would have been long in duration and a matter of questionable military importance. Some fittings of Turret II and its guns would have to be manufactured in the United States, but the specifications and plans were not available in Africa. The time and cost involved in manufacturing special dies and tools conforming to the metric system would have been prohibitively expensive. Accordingly, as was mentioned earlier, her four 380-mm guns were removed for use as spares and replacements for the *Richelieu*.

French naval constructors proposed several schemes to make use of the hull of the *Jean Bart*. One plan was to arm her with 330-mm guns and ultimately give her the crew of the old battleship *Lorraine*, but this plan was set aside. Two other schemes considered (see figure 3-4) were obvious attempts to complete the ship using whatever materials were available in Algeria and U.S. armament installed by an American shipyard.

Scheme A featured thirty 127-mm/38-caliber guns in fifteen twin mounts, sixty-four 40-mm Bofors in sixteen quadruple mounts, and a catapult at the stern. Aft, two 40-mm positions would replace the 152-mm centerline turret, and 127-mm/38-caliber mounts were to replace the two wing turrets. Changes in the superstructure and below decks aft would accommodate new magazines and additional aircraft in the enlarged hangar. The plan was not feasible; there was no real use for floatplanes in naval actions, and the antiaircraft armament would have eliminated too much offensive power.

Scheme B was to reconfigure her into a large antiaircraft support ship with thirty-four 127-mm/38-caliber guns in seventeen twin mounts and eighty Bofors in twenty quadruple mounts. These guns would have been excellent cover for a fast carrier group, while the four 380-mm guns would have been useful in shore bombardment. Only eight directors would have been provided for all the 127-mm mounts and none for the 40-mm guns.



The *Jean Bart* is shown in Casablanca on 3 July 1943. The four 380-mm guns of Turret I have been removed to replace damaged ones on the *Richelieu* or to be used for her spares. Temporary patches have been applied to the bow and stern damage seen earlier.

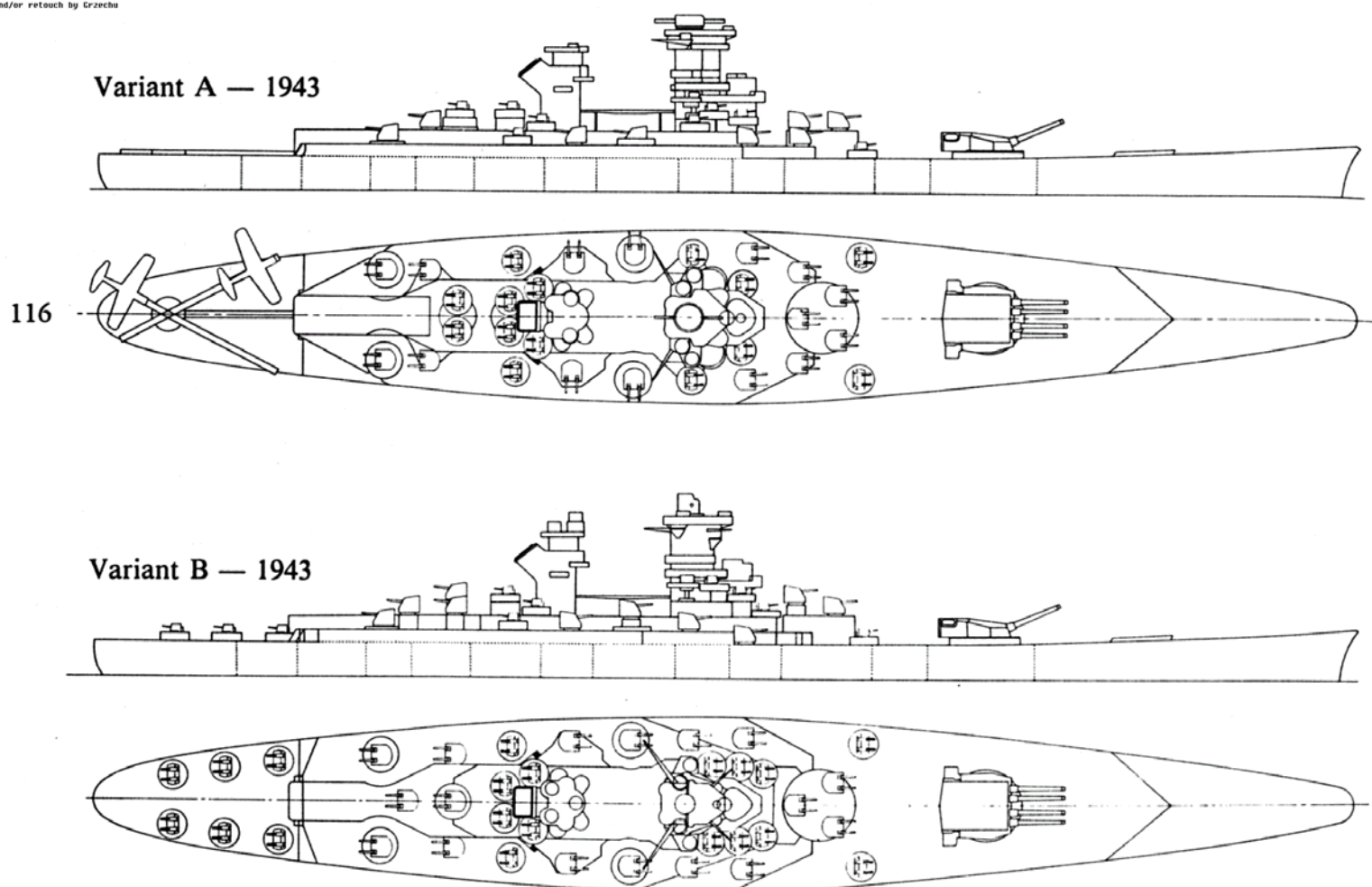


Figure 3-4. Two schemes proposed for hull of Jean Bart.

Neither plan was adopted, due to the inability of the U.S. shipyards to perform the work and the low military priority of such a ship. The *Jean Bart* served as a receiving ship until France was liberated, when it was decided to complete her as a battleship, and on 25 August 1945 she sailed for France.

By 12 November the Homet Drydock in Cherbourg was able to dock the *Jean Bart* for inspection of her underwater hull. Shell plating had to be examined and cleaned (this had not been done since June 1940), and it was important to determine the extent of battle damage. Inspection revealed a small amount of corrosion, but damage resulting from the grounding and the hole punched in the bottom forward of the rudder was more serious than had been anticipated. Over 200 square meters of bottom plating in the stern had to be replaced, and it was necessary to change the heel of the stern frame to avoid repetition of this type of damage. In both the *Richelieu* and *Jean Bart*, groundings of the stern had caused significant damage to the stern castings and surrounding plates.

After World War II, the future of the *Jean Bart* was the subject of many discussions and studies. A 1946 cost study was made of her completion as a battleship or her conversion to an aircraft carrier. The latter resulted in a cost of 5,000,000,000 francs (\$100,000,000). Furthermore, the carrier version could accommodate only 54 planes—insufficient for a modern fleet carrier—and would cost as much as a new 29,000-ton carrier. Completion as a battleship and modernization, however, would

only cost 40 percent as much. In addition, it was recognized that modernization should incorporate all the features of a modern battleship as indicated by the naval war in the Pacific and, in particular, the improvements necessitated by the wartime modernization and overhaul of the *Richelieu* in the New York Navy Yard. As the ship was 85 percent complete, it seemed reasonable to complete her as designed, but to modernize her to combine existing structure and weapons with all desirable improvements. Accordingly, the ship entered the Brest Navy Yard on 11 February 1946.

Principal modifications were to be made in the antiaircraft armament, the layout of the superstructure and conning tower, accommodations for officers and crew, and the correction of the draft. The draft at the full load had to be reduced to eliminate the danger of flooding the lower armor deck in a damaged condition. The problem was complicated by necessary weight increases due to modifications and improvements and an entirely new radar installation. Control of weight and draft was essential if the ship were to maintain her trial speed capability, because no increase in horsepower was contemplated. The weight breakdown included provisions for all modifications, and the Service Technique Constructions et Armes Navales in Paris and the Director of Naval Construction in Brest kept a careful check on the weights added and removed. Weight was saved by the extensive use of welding.

Combat operations with the *Richelieu*, and especially air attacks on American ships in the Pacific War, had shown the inadequacy of the original superstructure arrangement. In battle, the captain had only a limited view; radar could improve this, so it was decided to redesign the conning tower. The forward tower was widened to accommodate a navigation bridge at the top, the primary control station. A small shelter forward in the tower would protect the helmsman and the servotransmitters, and could protect the captain and other personnel on the bridge. The structure was lightly armored.

The importance of the antiaircraft battery and the requirement for constant air vigilance affected the redesign and required increasing the crew from the wartime complement of 1,550 to more than 2,150. The officers' quarters were severely restricted in size (junior officers went two to a room), and the admiral's quarters were reduced by nearly 50 percent.

The overload problem of the *Richelieu*-class battleships existed from the early design stages. There were also some underestimates of weights during the design, and when construction commenced, there were numerous additions and alterations made during the construction of both ships. Some changes occurred during the design period, but most took place after the keel had been laid. During the overhaul in the United States of the *Richelieu*, the draft and displacement were seriously affected. This condition could not be overlooked in the redesign after the war. Two remedies were considered: reduce the on-board weight, or increase the buoyancy at a given draft. The first was hardly possible with the new equipment and alterations proposed. The second could be accomplished by the addition of bulges (see Midship Section—*Jean Bart*) for the entire length of the armored citadel, with a maximum breadth of about 1.1 meters. Bulge plating was designed to resist a hydrostatic load and was connected to the main structure by bulkheads and framing. The existing framing arrangement favored this solution—the hull form was normal, with the transverse sections nearly vertical around amidships. It was sufficient to replace the thin shell plating by another of equal thickness, but different in shape in order to obtain the desired increase in buoyancy at any given draft.

Some limitations placed upon the bulge design were:

- Frictional resistance must not be unduly increased.
- Maximum underwater breadth must not prevent docking in existing facilities.

- Waterline beam must not increase to the point of excessive stability, which in certain sea states would cause hard rolling.

These limitations, especially with respect to the beam, did not allow the desired solution. However, the lines that were adopted gave these results:

- Ratio of drag resistance at the full-load displacement was not increased, but reduced for speeds near maximum.
- Draft was slightly reduced, bringing the lower armor deck above the waterline.
- Waterline beam was increased by 2.7 meters (more at half draft), thus increasing protection against torpedo hits.
- Metacentric height in the full-load condition was increased 0.19 meters over that of the *Richelieu*. The rolling period was not greatly reduced.

The bulges improved the underwater protection and partially eliminated the dangers, described later, inherent in the narrowness of the voids. Another additional advantage was that a contact explosion at half draft would be a meter or more farther away from the torpedo bulkhead, providing a formidable underwater protection system.

The new characteristics are tabulated in Table 3-5.

TABLE 3-5

Characteristics of Jean Bart after Reconstruction—1949

Normal displacement	42,130 tons (42,806 mt)
Full-load displacement	48,177 tons (48,950 mt)
Waterline length	794' (242 m)
Draft (light)	30.18' (9.20 m)
Armament	Main and secondary guns same as <i>Richelieu</i> Twenty-four 3.94" (100-mm) guns, paired Twenty-eight 2.24" (57-mm) guns, paired Twenty 0.79" (20-mm) guns, singles No aircraft
Speed	31.84 knots (normal) 32.13 knots (overload)
Shaft horsepower (normal)	160,627 (162,853 mhp)
(overload)	173,622 (176,028 mhp)
Endurance	8,000 miles at 14 knots
Protection	Same as the <i>Richelieu</i>

After the *Jean Bart* was modernized, there were marked differences between her and the *Richelieu*. The *Richelieu* had originally been designed to carry fifteen 152-mm guns in five turrets, but by 1940 she had only nine. The *Jean Bart*, in 1940, had had the same original secondary armament projected. By 1946, the principal threat to surface ships was air attack, and it was necessary to completely revise the arrangement and sizes of the secondary armament and antiaircraft battery. The 380-mm guns and machinery intended for the *Clemenceau* had been completed before the Armistice and had been seized at the Creusot Works during the German occupation. These guns were taken to Norway but returned to France after World War II. Their return made it possible to complete *Jean Bart* as a battleship.

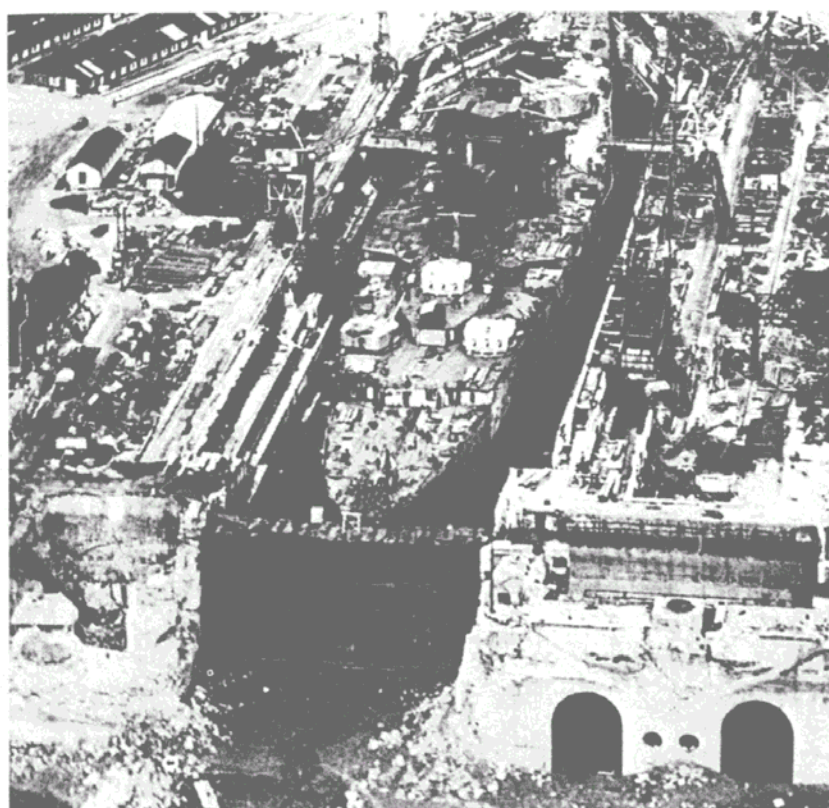
On 4 and 5 December 1948, the *Jean Bart* finally ran preliminary sea trials, and on 16 January 1949, acceptance trials. Despite financial difficulties that year, the ship was finally completed. Gunnery and speed trials during the first half of 1949 proved that the modernization had been successful. The *Jean Bart* was commissioned in April

1950 and began gunnery and training exercises with the French fleet. During preliminary sea trials she had made 32.13 knots for two hours on overload power at a displacement of 46,700 tons.

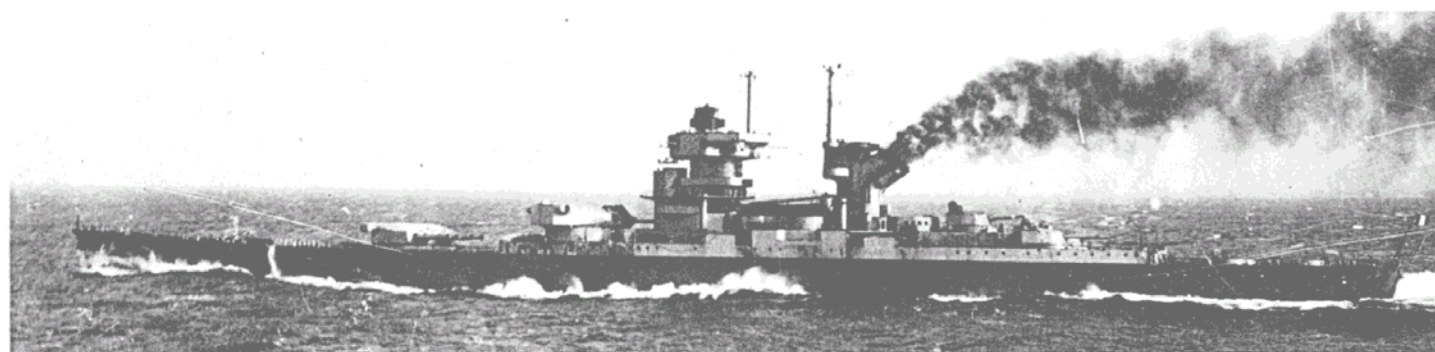
Post-completion history. The 57-mm antiaircraft battery was not installed until the winter of 1951-52, as production had been delayed by credit blockages in France in 1948-49.

In May 1955, the *Jean Bart* carried President René Coty to Denmark for a state visit. After her return to Brest she visited Oslo, Norway. She called at Newport, Rhode Island, from 8-11 July 1955 in commemoration of General Jean B. Rochambeau's landing during the Revolutionary War, after which she visited New York City. She then returned to France and was designated as the flagship of the French Mediterranean Fleet.

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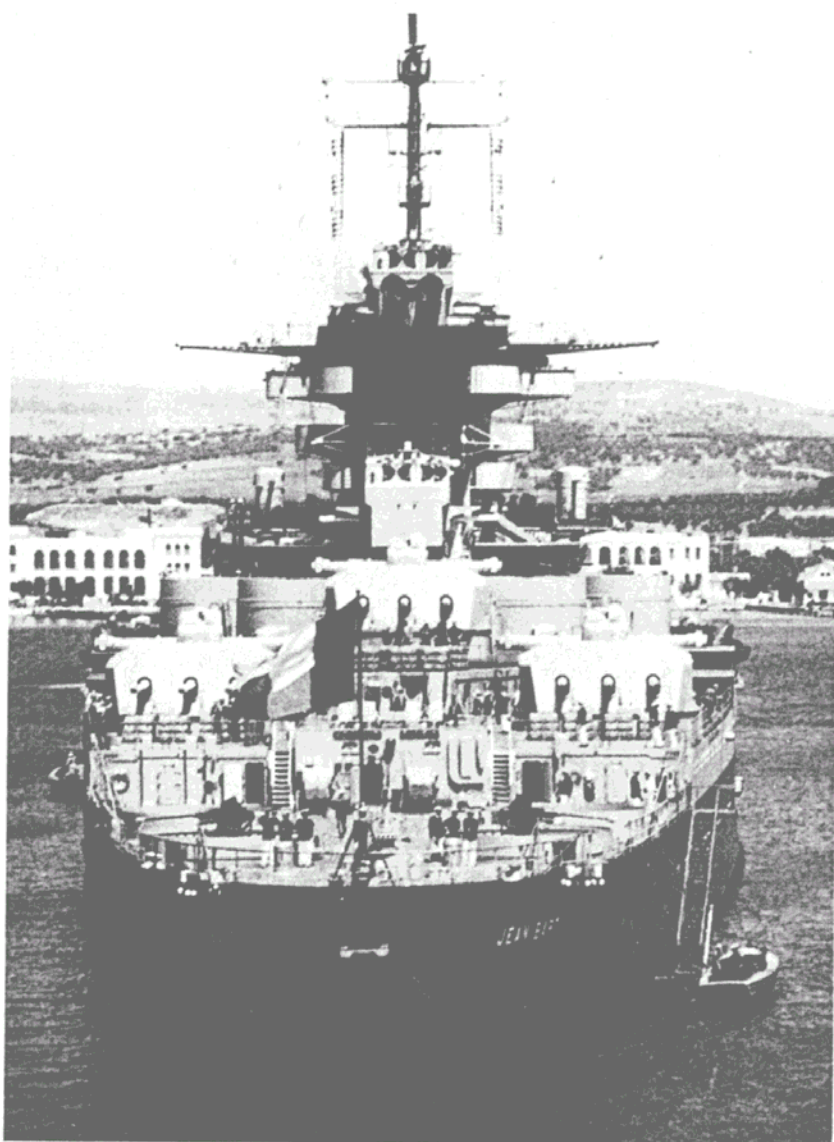
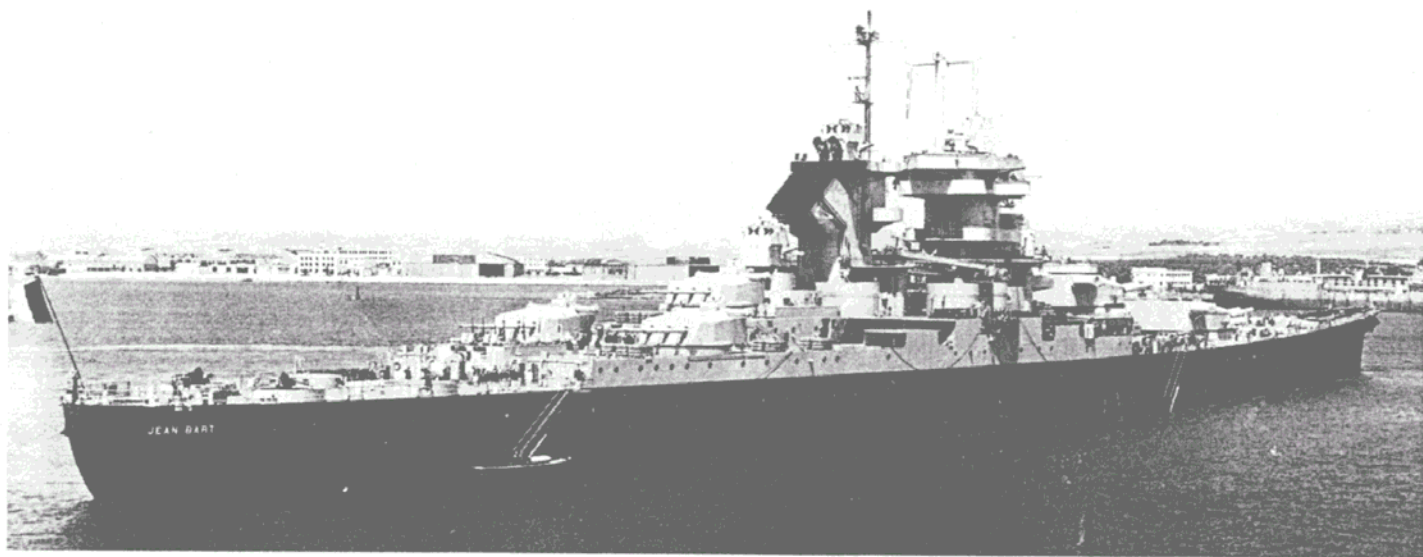


After World War II the *Jean Bart* entered the Brest Navy Yard to be completed. In this photo taken on 9 October 1948 work is under way on the battleship. Note the completed Turret I and the three 152-mm triple turrets aft. Damage sustained by the French navy yard from World War II bomb damage is still apparent in this photograph. (Musées de la Marine)

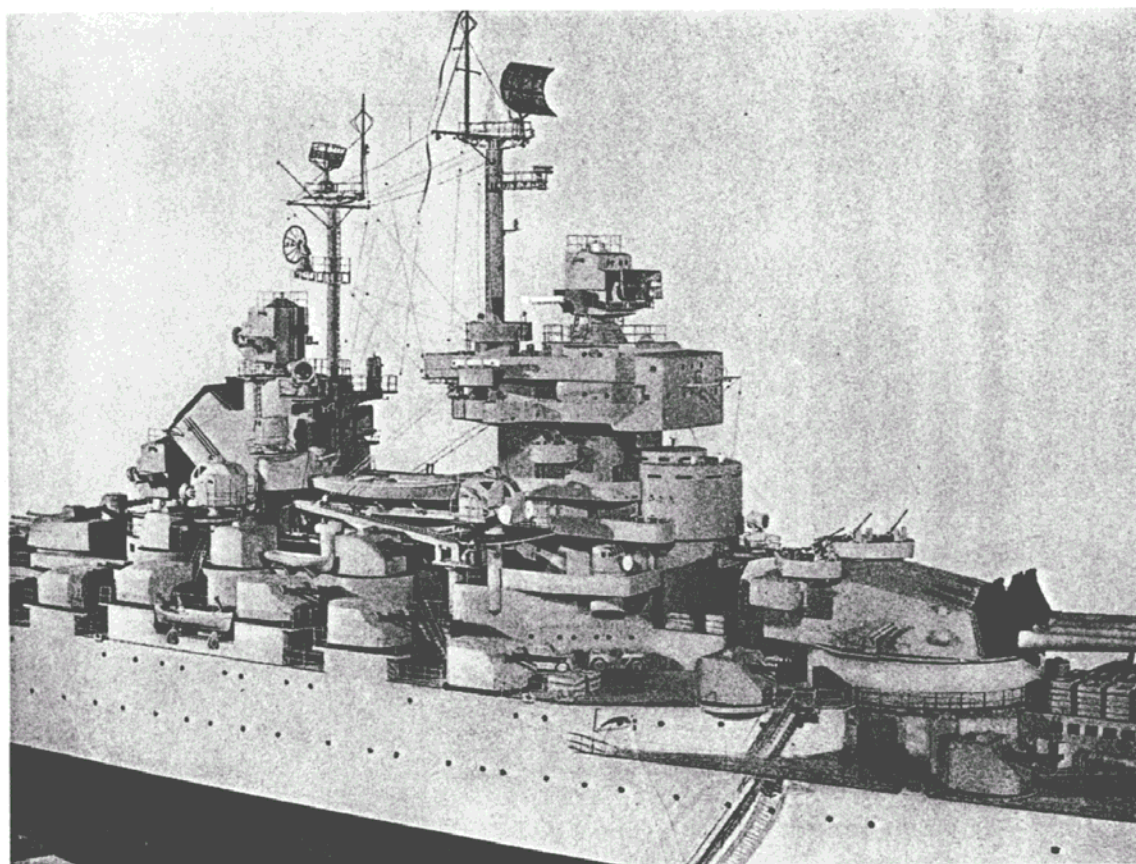


The *Jean Bart* is shown on trials in 1949. She entered service with the French fleet without her light antiaircraft battery. (Musées de la Marine)

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These two stern views of the Jean Bart show the changes made during the modernization. Gone are the hangar, catapult, and the mixed battery of 37-mm and 90-mm guns. A clear field of fire is provided aft for the three triple 152-mm gun turrets. (Musées de la Marine)



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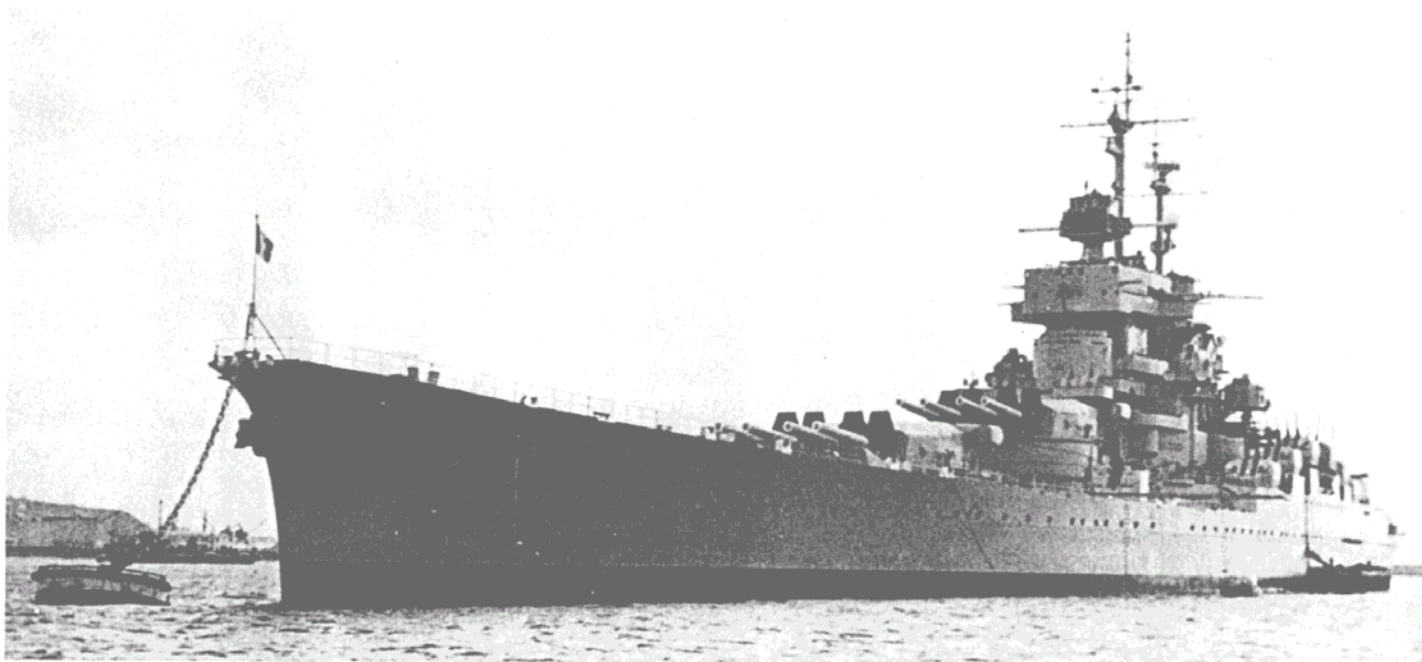
This view of a model of the Jean Bart at the Musées de la Marine shows the Jean Bart as she was finally completed in 1952. Six twin mounts of 100-mm guns are located outboard of the superstructure, while the twin-mounted 57-mm Bofors are arrayed above the 100-mm guns and abreast of Turret II. (Musées de la Marine)

On 24 October 1956, the *Jean Bart* sailed for Algiers to take part in the Suez Operation conducted by France and the United Kingdom. Her major role was to provide fire support for the landing forces. After a stop in Algiers, she reached Limassol Roads in Cyprus on 4 November. Five days later she sailed for Toulon.

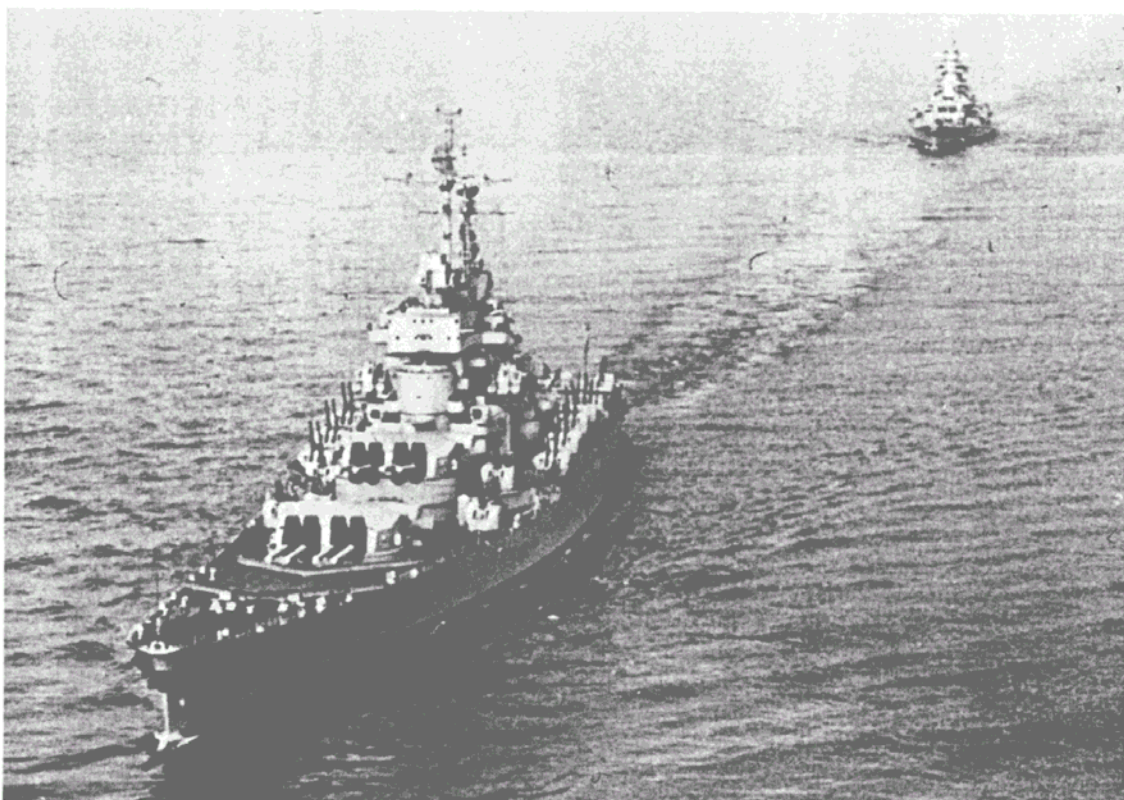
Final Disposition. The ship served in the Mediterranean Fleet until 1961, then became a gunnery school tender, and still housed gunnery school students in Toulon as late as 1969. Most of the anti-aircraft battery had been removed; the main battery was still in place. There was a proposal to turn the ship into a floating naval museum, but funds could not be raised, and she was made available for disposal on 15 January 1970. She left Toulon on 24 June to be broken up at La Seyne.

Clemenceau. The last two projected ships of the *Richelieu* class were never completed. The *Clemenceau* was only 10 to 15 percent complete at Brest when France was invaded. The Germans found the hull in the Salou Dock with the bow and part of the stern missing. They realized it was impossible to continue construction because of the lack of proper steel, plans, and cooperation of the navy yard work force, as well as

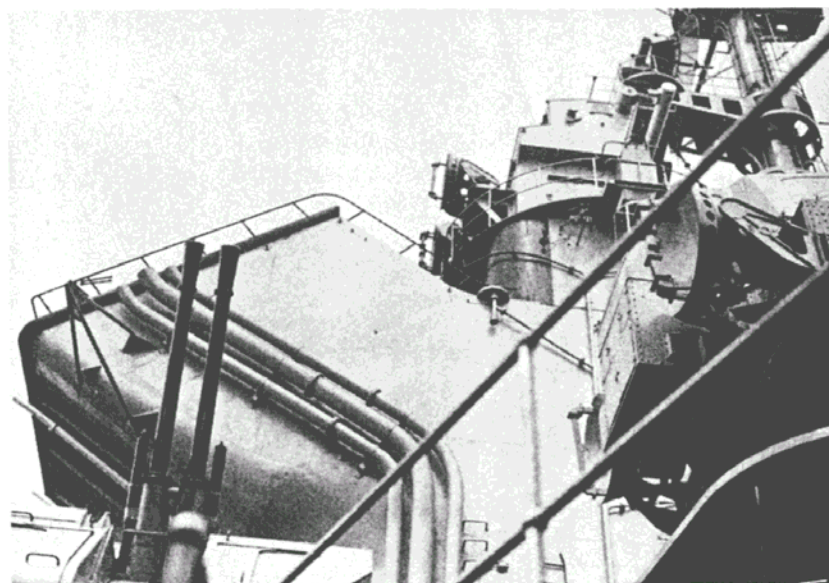
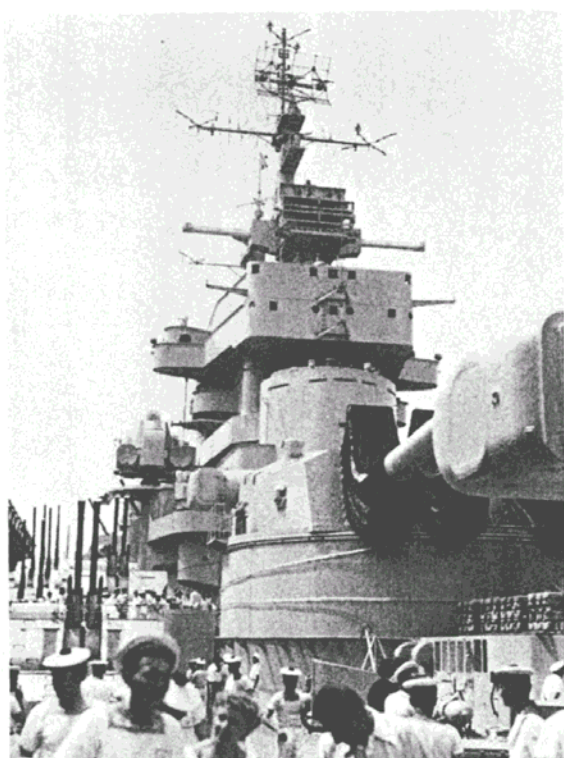
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This bow view of the Jean Bart on 24 January 1953 shows the newly installed 100-mm and 57-mm antiaircraft armament. Note also the forward command tower which was also changed during her postwar conversion. (Service Cinéma des Armées)



This photograph shows the Jean Bart (foreground) and Richelieu (rear) during maneuvers in the Mediterranean on 30 January 1956. This was the only time they operated together as a unit. Shortly after this, the Richelieu went to the reserve fleet and was used as a school ship in Brest.



This close-up of the main command tower, radar, and antiaircraft armament was taken in July 1955 when the *Jean Bart* was in New York City as part of the 175th anniversary of Rochambeau's landing during the American Revolutionary War. (R. J. Scott)

A close-up of the *Jean Bart* shows the mast-stack detail, the twin-mounted 57-mm Bofors, rangefinders, and radar. (R. J. Scott)

constant air attacks by the Royal Air Force. Nevertheless, they needed the building dock. Before the *Gneisenau* and *Scharnhorst* reached Brest in March 1941, the hull was floated out and moved to Landevennec, where Allied bombers sank it on 27 August 1944.

Gascogne. The *Gascogne* was canceled on the eve of the German occupation. She was to have been totally different from her predecessors in the disposition of armament and general arrangement. The Loire Shipyard was to construct the ship, install guns, and conduct the trials. That yard also made structural and armor studies, and planning had advanced to the point where material procurement could begin. Parts of her outfit had arrived while the *Jean Bart* was under construction; this was shipped to the Toulon Naval Base before the German occupation. No work on the propulsion plant or any actual construction of sub-assemblies was ever begun.

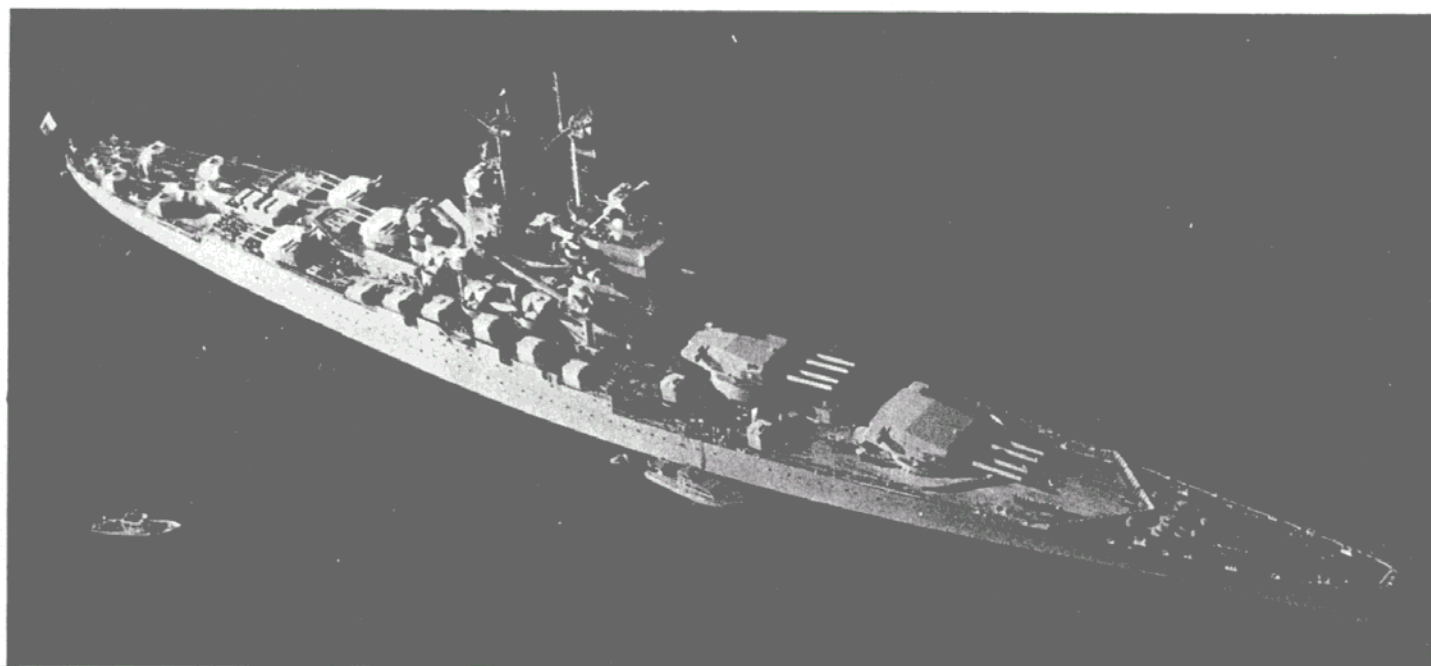
The close cooperation of the Penhoët and Loire Shipyards ended with the construction of the *Jean Bart*, as the Penhoët yard had contracted to build the carriers *Joffre* and *Painlevé* without the assistance of the Loire Shipyard.

Armament. The principal characteristics of guns for the *Richelieu* class are tabulated in Table 3-6.

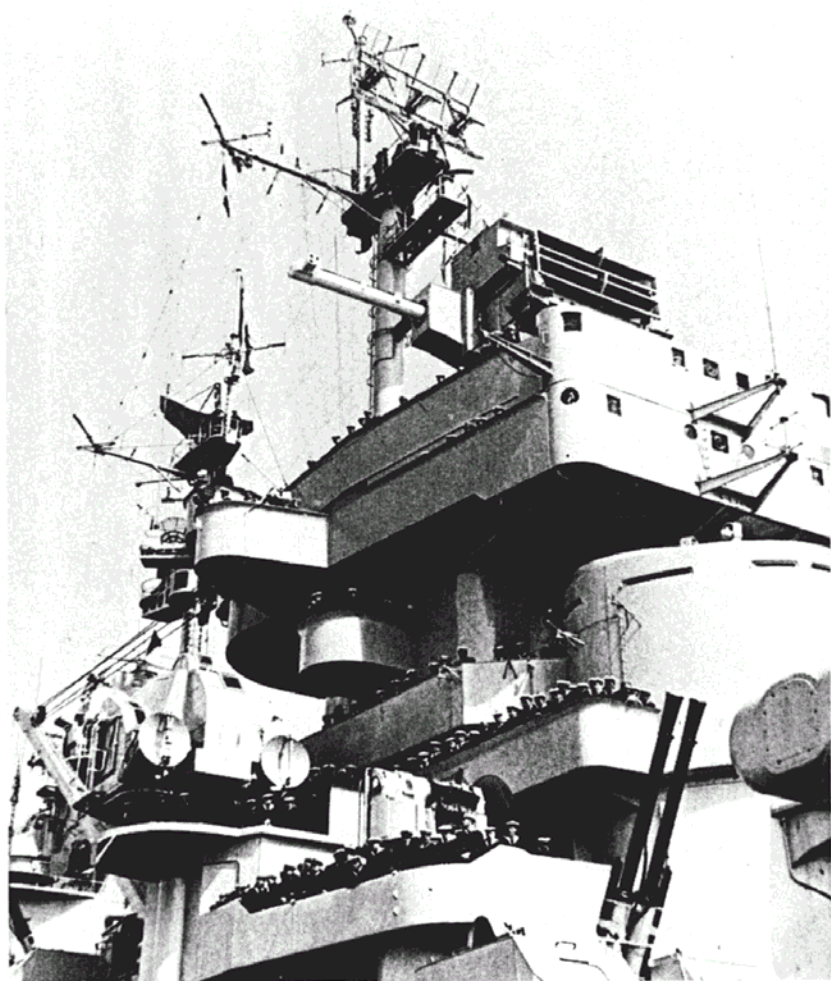
TABLE 3-6
Gun Characteristics

Gun	15"/45	(380 mm)	6"/55	(152 mm)
Shell weight (lbs)	1,949	(884)	123	(56)
Muzzle velocity (fps)	2,575	(785)	2,854	(870)
Maximum range (yds)	41,065	(37,550)	28,948	(26,470)
Maximum elevation	35°		85°	
Gun	3.9"/45	(100 mm)	1.46"	(37 mm)
Shell weight (lbs)	33	(15)	1.73	(0.785)
Muzzle velocity (fps)	2,477	(755)	2,592	(790)
Maximum range (yds)	17,104	(15,640)	8,749	(8,000)
Maximum elevation	80°		80°	
Gun	0.59"	(13.2 mm)		
Shell weight (lbs)	...			
Muzzle velocity (fps)	2,625	(800)		
Maximum range (yds)	7,847	(7,175)		
Maximum elevation	90°			

Main battery. The main battery was mounted forward of the superstructure, as in the *Dunkerque* and *Strasbourg*, while the nine 152-mm guns were mounted aft. The 380-mm gun (Model 1935) was capable of penetrating 378-mm armor plate at a range of 20,025 meters. The bursting charge for the armor-piercing shell was 23 kg of explosive (picric acid + 20 percent nitronapthalene). The quadruple mounting of the 380-mm guns was basically the result of weight considerations, as the *Dunkerque* and *Strasbourg* design had demonstrated that multigun turrets produced marked weight savings. The eight 380-mm guns in quadruple turrets weighed 4,952 metric tons, much less than nine 406-mm/50-caliber guns in triple turrets, which weighed some 6,945 metric tons. Quadruple turrets permitted a better salvo grouping, more guns, and a shorter armor box, which in the *Richelieu* weighed approximately 25 tons per meter.



The Jean Bart, second ship of the Richelieu class, as she appeared in July 1955 with her new armament of 100-mm and 57-mm guns and modified superstructure.



This is a view of the new command tower fitted to the Jean Bart during her postwar reconstruction. Note the new radar equipment added during her conversion. (Service Cinéma des Armées)

The main purpose of a battleship in 1934 was to destroy an opponent as quickly as possible, yet provide sufficient protection against the largest gun caliber. It was believed that these objectives were achieved by placing both main-battery turrets forward, which concentrated the main armament and reduced the length of the armored citadel, thereby permitting greater armor thicknesses to be employed. Other advantages of placing the main battery forward were that there was less stack interference, 100 percent efficiency of fire from the bow, a very desirable segregation of the main battery from the aviation activities and boat stowage, and superior fire control. In an attempt to eliminate gas interferences with the gun directors, a swiveling funnel was designed but later deleted because of overweight problems. The French naval constructors, after carefully evaluating the Battle of Jutland, concluded that stack gases could create a serious visibility problem in a clash of battleships and could also prevent effective gunnery at a crucial moment in battle. To provide as much main-battery coverage as possible, Turret I had a training arc of 300 degrees, while Turret II had 312 degrees. The superstructure was specially contoured and lightly armored to permit such large training arcs for main-battery turrets.

Studies done by the Loire Shipyard in 1939-40 indicated that a redistribution of the main armament forward and aft resulted in a better arrangement of the antiaircraft battery by permitting more mounts with wider arcs of fire. Therefore, alterations in the *Gascogne* produced an arrangement of all main and secondary battery guns on the centerline with one quadruple 380-mm and two superimposed triple 152-mm turrets forward, and one quadruple 380-mm and one 152-mm triple turret aft. The training

arcs of the main battery were limited to 275 degrees to permit the placement of more antiaircraft guns in areas free from the blast of the main and secondary guns. As a result, the antiaircraft armament in the *Gascogne* was the strongest of all four *Richelieu*-class battleships as originally conceived; eight twin 100-mm mounts replaced the 152-mm guns because of their deficiency in the rate of fire; two quadruple 37-mm gun mounts, six twin 37-mm gun mounts, and nine quadruple 13.2-mm machine-gun mounts completed the antiaircraft battery. The entire arrangement determined the superstructure contour and the location of the propulsion plant. Any increases resulting from these changes would have been permissible in 1939, because treaty restrictions were no longer in effect. The only problem was whether the waterline would be above or below the lower armor deck.

In the *Richelieu*, *Jean Bart*, and *Clemenceau*, the turrets were sufficiently separated by an 11-meter-long watertight compartment for the emergency diesel generators and a magazine for nearby light machine guns, diminishing the possibility that a single shell or torpedo hit could render both turrets useless. This separation forced the concentration of the propulsion plant, and as a consequence the location of the superstructure was farther aft than in most battleships. There was an undesirable concentration of control and officer-accommodation spaces near the bridge tower. The propulsion plant also was located farther aft than was done on most battleships of the period, necessitating its unusual compactness, since the hull lacked adequate volume for a more conventional machinery arrangement. Such limitations were accepted, however, for the more important considerations of balancing the armament against displacement and achieving the 35,000-ton limit.

Each turret was serviced by two separate sets of shell and powder magazines, each pair on the same deck, fore and aft, instead of the conventional upper and lower deck arrangement. The two pairs were stacked, one above the other, on two decks, each pair supplying the two guns in a half turret. The unorthodox location of the main battery caused no operational difficulties. Firing tests in the *Richelieu* showed no adverse blast effects on the bridge tower, so the designers considered the arrangement successful.

The quadruple turrets were designed for a firing-loading cycle of 25 seconds, fast for such heavy artillery. The guns could be loaded at any angle of elevation; the vigorously rammed shell was kept in place by its own driving bands. The four cartridge bags were rammed by two, the two first remaining steady by inertia during the ramming of the last ones, and the four were kept immovable during the closing of the breech. This was obtained by a "semi-flexible rammer," which permitted a high rate of fire. Each of the turrets was divided into two half turrets (with their own hoists) by an armored bulkhead, above which the turret officer was located "horseback fashion." The bulkhead was flameproof so that one side of a turret could continue in action if the other were disabled. The turrets were electrically driven with the guns paired in each turret. There were two dredger hoists to a handling room and four upper hoists (one for each gun). Chain rammers on the cradles permitted loading at any angle of elevation. Complete ramming time was 13.5 seconds. The breeches were operated hydro-pneumatically and opened automatically upwards during runout. Opening and closing time was 3.5 seconds. A total of 104 rounds per gun were carried in each magazine.

Secondary battery. The secondary armament consisted of nine triple-mounted 152-mm/55-caliber guns (Model 1930) which could penetrate a 122-mm armor plate at 9,970 meters. It was first planned to mount five triple turrets in the *Richelieu* and *Jean Bart* to serve as dual-purpose weapons. Although the maximum elevation was 85 degrees, a 90-degree elevation was desired. The modest rate of fire and the fact that they could not be loaded at maximum elevation limited their effectiveness in antiair-

craft defense. In June 1939, to augment antiaircraft defense and obtain a greater volume of fire, the two forward triple 152-mm turrets were replaced by twelve 100-mm/45-caliber guns (Model 1925) in twin mounts. It was felt that antiaircraft protection was more important than the limited need for defense against destroyer or cruiser attack. Furthermore, the 152-mm turrets, once installed, would have required additional time for full development of their antiaircraft capabilities, and delays seemed inevitable in the delivery of the automatic 37-mm mounts. World War II proved that such large guns were not as effective as smaller caliber guns against aircraft. The secondary armament provided the main fire power over a 70-degree arc aft and also evolved into a concentrated heavy antiaircraft battery.

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These battleships were among the first to carry a dual-purpose armament, although the 152-mm dual-purpose guns had questionable antiaircraft defense value due to their slower rate of fire in comparison with slightly smaller guns used by the United States and Great Britain. These guns were designed to maintain long-range antiaircraft barrage fire with high-explosive shells instead of shooting down aircraft individually. Barrage fire had proved to be of limited effectiveness during World War II. The disposition of the secondary turrets in the *Jean Bart* and *Richelieu* was slightly different from that used in the *Dunkerque* and *Strasbourg* in that the centerline turret was forward and not aft of the aftermost outboard turrets. This new arrangement permitted a much wider arc of fire for these outboard turrets. The arrangement also allowed both turrets on a given side to follow aircraft diving on a ship from a position forward of the bow. With the development of more effective antiaircraft guns, the 152-mm battery of the *Richelieu* was changed in 1939 from fifteen guns in five turrets to nine guns in three turrets.

The secondary armament of the *Clemenceau* and *Gascogne* was also affected by the needs of antiaircraft defense. As the *Clemenceau* was under construction in 1939, only a limited rearrangement of the secondary battery was undertaken. One of the five 152-mm triple turrets was eliminated and the triangular arrangement aft—as in the *Dunkerque*, *Strasbourg*, *Richelieu*, and *Jean Bart*—was discarded, and an earlier scheme, considered during the preliminary design as an alternate, was chosen instead. Two turrets were to be located slightly abaft the conning tower, but forward of the funnel. Two were to be located abaft the funnel, one superfiring over the other. Six twin mounts of 100-mm/45-caliber guns and two quadruple 37-mm machine-gun mounts were dispersed around the superstructure. Nine quadruple 13.2 machine-gun mounts completed the antiaircraft battery. The *Gascogne* had only three 152-mm triple turrets, but a better grouping of the lighter weapons.

All of the secondary turrets were equipped with two different hoist systems to enable an instantaneous shift from armor-piercing to high-explosive shells. Even more interesting was the fact that the two forward outboard turrets were situated slightly aft of and outboard of their common magazine. These guns were separated from their magazines by some 28 meters, making necessary an ammunition hoist system which featured horizontal and vertical movement. This was accomplished by the use of a chain drive with a break in the ammunition hoist system at the turntable. The total system was to be similar to that used in the twin 130-mm mounts of the *Dunkerque* and *Strasbourg*. The system had been proven in highly successful trials in the plant of St. Chamond. The centerline and after wing turrets were positioned directly over their magazines. The 152-mm turrets in the *Gascogne* featured centerline mountings and individual magazines for each of the turrets.

The development of the 152-mm turret with its capability of high-angle fire introduced much difficulty in its design and subsequent operation. Because of the outbreak of war in 1939, development problems with the turret were overshadowed by the needs of production for proven artillery equipment. As a result of this, the number of

152-mm turrets on the *Richelieu* and *Jean Bart* was cut from five to three, despite the fact that the barbettes and magazines for these guns had been installed. In those guns delivered to the *Richelieu*, the maximum elevation was only 75 degrees instead of the 90 degrees sought in the design specifications. After the war, continued work on the mechanisms of the 152-mm turrets in the *Jean Bart* and *Richelieu* permitted an 85-degree elevation to be attained in the firing of these guns.

The rangefinding equipment for these French battleships was elaborate. The forward control tower consisted of a rigid core of sufficient dimensions to accommodate all instruments and personnel necessary for rangefinding and navigation. The armored core offered sufficient protection against heavy shell fragments. The main gun director, located at the highest level of the forward control tower, had a 13.5-meter rangefinder topped by a 152-mm director equipped with an 8-meter rangefinder. A 3-meter navigational rangefinder was located over the conning tower and a second was positioned on the lower superstructure deck. A 5-meter rangefinder was located on the mast-stack structure with a reserve main-battery rangefinder located between the forward and after 152-mm turrets. This rangefinder had a blind arc forward of some 90 degrees. Each of the 380-mm turrets was fitted with two 13.5-meter rangefinders, and two 8-meter rangefinders were provided for each 152-mm turret. An optical system was also provided which permitted stereoscopic viewing of the target's motion.

The 380-mm guns could be fired under local control or from a centralized control station located between the upper and lower armor decks. The elevating and training of these guns could also be remotely controlled.

The 152-mm battery could be locally controlled in action against surface ships or aircraft. Since the turrets were equipped with servocontrollers, they could also be remotely controlled from three gunfire-control positions. The secondary turrets were also cross-connected to permit firings in groups. A centralized lookout position permitted simultaneous fire on three different targets. This arrangement of rangefinders for the secondary and primary batteries was substantially altered with the addition of fire-control and navigational radars during the modernization of the *Jean Bart* after World War II.

Antiaircraft battery. The 100-mm mounts were chosen in 1939 to replace two of the five 152-mm turrets to improve medium-range air defense. In addition, production difficulties would have made it impossible to deliver all the 152-mm turrets on time for both the *Richelieu* and *Jean Bart*. Although the 100-mm guns were smaller than the guns they replaced, they had a higher rate of fire and were more effective against aircraft.

The lighter antiaircraft batteries of the *Richelieu* and *Jean Bart* underwent several modifications during their service. The four quadruple 13.2-mm machine-gun mounts were removed in 1939. The 37-mm twin mounts actually installed in the *Richelieu* were of the semiautomatic type used on the *Dunkerque* and *Strasbourg*, as emergency measure due to the delayed production and delivery of the automatic type mount. A prototype 37-mm machine gun installed on the old patrol vessel *Amiens* proved very successful during the evacuation at Dunkirk.

During the modernization of the *Richelieu* at the New York Navy Yard in 1943, the light antiaircraft armament was completely modified. The ship received fifty-six 40-mm Bofors machine guns in fourteen quadruple mounts with their own individual rangefinders and Mark 51 directors. Fifty single-mounted Oerlikon 20-mm machine guns were also added. The 40-mm guns could fire at a rate of 120 rounds per minute, and automatic destruction of the projectile occurred at a range of 3,600 meters. During wartime, 122,000 cartridges of 40 mm were carried, while in peacetime only 96,000 rounds were carried. The 20-mm guns could fire at a rate of 470 rounds per minute and

had a maximum ceiling of 1,200 meters. During wartime, 84,000 cartridges were carried, but only 42,000 were carried in peacetime. The characteristics of these guns are tabulated in Table 3-7.

TABLE 3-7

Antiaircraft Gun Characteristics

Gun	3.9" (100 mm) (Mod 1945) ¹	2.24" (57 mm)
Shell weight (lbs)	29.36 (13.32 kgs)	5.73 (2.60 kg)
Muzzle velocity (fps)	2,805 (855 m/s)	3,018 (920 m/s)
Maximum range (yds)	18,876 (17,260 m)	—
Maximum elevation	90°?	90°
Gun	1.57" (40 mm)/56	0.79" (20 mm)/70
Shell weight (lbs)	1.98 (0.90 kg)	0.80 (360 grams)
Muzzle velocity (fps)	2,890 (881 m/s)	2,740 (836 m/s)
Maximum range (yds)	11,189 (10,079 m)	4,800 (4,390 m)
Maximum elevation	90°	90°

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Wartime operations revealed that the 20-mm and 40-mm weapons were not effective against attack by high-speed suicide aircraft, such as the Japanese "Baka" bomb or drones with explosive charges. These deficiencies in the armament of the *Richelieu* were not to be repeated in the *Jean Bart*. The French Navy did not want a duplication of the type of armament used on the *Richelieu*—either in its caliber or its disposition. The 100-mm guns (Model 1930) were to be replaced by Model 1945 guns with longer barrels, which could be loaded beneath the mount. There were six radar-controlled mounts located per side. The 40-mm Bofors armament of the *Richelieu* was ruled out for the *Jean Bart* by the Conseil Supérieur, which was convinced that the 40-mm guns could not provide effective antiaircraft defense against high-speed aircraft and postwar pilotless planes. Wartime operations in the Pacific indicated a need to completely destroy aircraft at long ranges from a ship and also proved that the 20-mm and 40-mm armament was not sufficient for that purpose. The new 100-mm guns were positioned in the superstructure clear of blast effects from the 380-mm and 152-mm guns. The 57-mm guns provided the "close-in" protection, and fourteen mounts were dispersed in the superstructure or grouped aft on the quarterdeck. Ten 20-mm machine guns completed the armament, but later these guns were removed. Advancing postwar aviation and guided-missile technology made the guns of limited value against air attack. The *Jean Bart* definitely had one of the best conventional antiaircraft systems ever installed in any capital ship.

Aircraft. When the design of the *Richelieu*-class ships commenced in 1934, aircraft spotting, reconnaissance, and limited offensive missions were considered normal functions for battleship floatplanes. In fact, the main battery forward on these ships facilitated aircraft operations astern. Each ship in the class was to have carried five seaplanes, three in the hangar and two on quarterdeck catapults at the stern, where the deck was one level lower, to minimize blast effects from the secondary battery when firing aft. The actual aviation complements were as follows:

- The *Richelieu* was completed with the designed complement, but hangar and catapults were removed at the New York Navy Yard in 1943 as a weight compensation and space provision for 40-mm and 20-mm gun positions.
- The *Jean Bart* had seaplane facilities, but when finally completed after the war, she had no aircraft.

- The *Clemenceau* design was modified to delete aircraft as a weight compensation. She had a hangar structure like the *Richelieu* and *Jean Bart*, but no catapult.
- The *Gascogne* had a complement of two floatplanes and a single catapult with a below-deck hangar at the stern. If the ship had been completed, she probably would not have had any aircraft.

Armor Protection. The *Richelieu*-class battleships had one of the most effective protective systems ever designed for a battleship. In general, the immunity zone in the original design was 18,800 to 29,800 meters against the 380-mm/45-caliber gun. The deck armor system was designed to withstand a 500-kilogram bomb dropped from 4,700 meters. The comparatively short citadel was very strongly protected with a relatively deep underwater protection system extending its full length. Heavy armor protection outside the citadel was concentrated mainly over the steering gear, shafts, and the conning tower. Forward of the armor box, there was splinter-deck protection carried to the forepeak tank, and the large compartment immediately forward of the armored citadel was filled with a water-exclusion material. The deck armor was a modified "turtle deck" design combined with an inclined side armor belt and an upper and lower armor deck. This arrangement of armor decks provided good support for the main side belt. The upper edge was rigidly supported by the main protective deck, while the splinter or lower armor deck offered support at the lower slope. Both of these special treatment steel decks were very solid, strong, heavy, and good strength members.

The French naval constructors advocated the use of special treatment steel as backing for major armor protection. This increased the effective thickness of armor and provided splinter protection against fragments from the armor which could have been projected into the ship on a near penetration.

The main side belt was internal, sloped, and uniform in thickness throughout the armored citadel. In the *Richelieu*, *Jean Bart*, and *Clemenceau*, this belt was to be 330-mm thick, sloped at 15.5 degrees to gain additional effective resistance. At approximately 1.5 meters below the design waterline, the side belt began to taper to 170 mm at its termination on the lower armor deck slope. The armor belt extended 3.38 meters above and 2.0 meters below the design waterline. The lower armor deck was to have been 0.98 meters above the design waterline of 9.17 meters.

Deck armor. Horizontal protection was based on the conviction (circa 1935) that the principal damage to upper surfaces of the citadel would be from level bombing attacks; therefore, armor-deck thicknesses were predicated upon armor-piercing bombs dropped from aircraft rather than shell penetration at extreme ranges. As an added measure, armor above the main magazines was thicker than required. Main and lower armor decks had the thicknesses summarized in Table 3-8.

The armor deck below the main armor deck was intended to prevent shell or structural fragments from reaching the vitals. This deck was sloped downward to its outboard extent at an angle of 49.5 degrees, and its armor thickness was increased from 40 mm to 50 mm to augment the side armor belt and provide a better connection with the main side belt and thereby increase the rigidity. Aft the citadel, thickness ranged from 100 mm over the shafts to 150 mm over the steering-gear room. Near its outboard boundary, the deck sloped some 45 degrees to provide side protection for the shafts and steering gear in the absence of a side armor belt and to protect the power leads from the generators. The lower armor deck extended beyond the forward armored bulkhead to the collision bulkhead for splinter protection.

TABLE 3-8

Deck Armor Thicknesses

	<i>Magazines*</i>	<i>Machinery</i>
Main deck		
inboard	6.69" (170 mm)	5.91" (150 mm)
outboard	6.69" (170 mm)	5.91" (150 mm)
Second deck		
inboard	1.57" (40 mm)	1.57" (40 mm)
outboard	1.97" (50 mm)	1.97" (50 mm)
Total armor		
inboard	8.26" (210 mm)	7.48" (190 mm)
outboard	8.66" (220 mm)	7.88" (200 mm)

* Thicknesses over the secondary gun magazines were the same as those over the propulsion plant.

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Conning tower. The French Navy still considered that the conning tower and communication and power lines to the armored citadel required heavy protection. Armor was supported by two-plate construction, with plates 17-mm thick on the sides and 11-mm thick under the roof armor. An armored communications tube was provided between the conning tower and armor box. The only other position in the bridge tower which had armor protection, other than the conning tower, was the access tube to the main gun director. A 30-mm armor plating provided splinter protection for communication and power lines.

Armored bulkheads. There were three main transverse armored bulkheads. The smallest, abaft the steering-gear room, had a uniform thickness of 150 mm. Bulkheads at the extremities of the citadel varied in thickness according to the angle at which 380-mm shells were expected to strike and the amount of structure and armor they would have to penetrate to gain entrance to the vitals. The forward bulkhead has a thickness of 233 mm except for a strake between the upper and lower armor decks, where it increased to 355 mm to protect the magazines of Turret I. Outboard of the torpedo bulkhead and below the armor deck it was only 165-mm thick, because of the shielding effect of the side armor carried forward of the bulkhead. The after bulkhead was 233-mm thick except for a small segment outboard of the torpedo bulkhead and below the slope where it decreased to 145 mm.

Turret armor. The main turrets and barbettes were extensively protected. Turret-deck armor (150-mm/50-mm thick) in combination with side and overhead armor, protected the magazines against bombs and shells. Thicknesses (face plate, 430 mm; roof plate, 170 mm) were based on studies to determine the best possible protection compatible with a standard displacement. The barbettes had 405-mm face-hardened armor plate superimposed on strakes of 20-mm thicknesses. This two-plate construction was similar to that employed in the structure of the conning tower. Barbette armor was of constant thickness on its periphery and above the main armor deck; below that deck it decreased to 85-mm between the armor decks because of the heavy deck protection over the magazines.

Armor for the secondary armament in modern battleships was often a weakness in their protective systems, and the *Richelieu*-class ships were no exception. The 152-mm turrets had only limited armor protection, although it was greater than in most battleships. If it had been thicker, then the draft and displacement would have increased beyond desired limits. The main ammunition passage for the entire secondary battery was vulnerable to heavy-caliber shellfire.

Splinter protection was provided for the intakes/uptakes and the superstructure. An armored enclosure of 20-mm noncemented armor plate was provided against fragmentation damage, with no accesses through the sides, and it was arrayed around the central intake and uptake trunk to the boilers. This protection was carried one deck above the upper armor deck. Within this enclosure, special armor gratings were used over openings in the armor deck, required for ventilation and the boiler uptakes. The superstructure periphery and the rangefinder enclosures were constructed of 10-mm special treatment steel. This type of protection excluded practically all fragments from antiaircraft projectiles and 50-kg bombs more than 50 meters away, or 500-kg bombs more than 75 meters away. The 20-mm protection for the uptakes excluded all fragments of a 50-kg bomb more than 20 meters away. Vital spaces above the upper armor deck were protected with 6.7-mm splinter bulkheads, and access to these compartments was through doors with high sills.

There were few changes in the *Gascogne's* armor protection, except that the magazines for the secondary armament were better protected than in other ships of the class. With the secondary and main armament arranged fore and aft, it was possible to place the secondary gun magazines under the heavier 170-mm deck protection, although the turret barbettes still had only 100-mm armor. The major difference in the armor protection was the reduction of the main side belt thickness from 330- to 320-mm. The horizontal armor protection was the same as in the *Richelieu*, but thicknesses were redistributed to correspond with the change in the main-battery disposition. The decrease in the main side armor was the result of the increase in the length of the armored citadel of 3.65 meters and the need to save weight.

The armored citadel in the first three *Richelieu*-class ships was 131.45 meters long—54.2 percent of the waterline length. In the *Gascogne*, it was 135.1 meters—55.8 percent of the waterline length—because of the separation of the main turrets fore and aft and the relocation of the secondary turrets to an all-centerline arrangement. The armor protection—a total of 16,700 metric tons—was more extensive and thicker than in the *Dunkerque* and *Strasbourg*. The ratio of armor weight to the trial displacement, however, was only slightly more in the *Richelieu*, as the comparison in Table 3-9 shows.

TABLE 3-9

Comparison of Armor Weight—Dunkerque vs. Richelieu

	<i>Dunkerque</i>		<i>Richelieu</i>	
	Tons	Percent*	Tons	Percent*
Hull	8,560	27.2	12,180	27.5
Turret	2,720	8.6	4,280	9.6
Total	11,280	35.8	16,460	37.1
Trial displacement	31,500		44,250	

* Percent of protection, based on trial displacement (metric tons).

Side protection system. Underwater protection had been studied thoroughly during the design and construction of the *Dunkerque*. The 1/10th scale-model tests of the *Dunkerque* side protection system at Gâvre confirmed that the sloping armor belt was superior and that it would be advantageous to place water-exclusion material adjacent to the torpedo bulkhead, particularly near the main-battery magazines where the system decreased in width, and in the compartment bounding the shell in the side protection system for the length of the armored citadel. Such studies in future capital

ships continued, and a series of underwater explosion experiments—contact and noncontact—were conducted at Lorient in March 1934 on representative models of 4/10th scale with 300-kg TNT equivalent charges. These indicated that the torpedo protection should be at least 4.9 to 7 meters deep. However, the explosions produced less damage than in the 1/10th scale experiments, leading the French naval constructors to conclude that the magnitude of damage produced in the 1/10th scale model would be produced by a 1,200-kilogram charge in full scale. These experiments pointed out the difficulty of relating damage in models to damage in full scale ships, and this is why many navies used full-scale caissons to test out their side protection systems. It was decided early in the preliminary design that the *Richelieu*-class battleships would have a side protection system similar to that in the *Dunkerque*-class battlecruisers, but with improved protection at the ends of the armored citadel. This meant that the system would be capable of withstanding 300-kilogram charges in contact with the ship's side at a distance of 3.5 meters below the design waterline of 9.17 meters. The principal characteristics of the torpedo defense system are summarized in Table 3-10. Between the shell plating and torpedo bulkhead, there were four spaces—void, void, liquid-loaded, and void (see Midship Section). The void wing compartments outboard of the armored citadel and adjacent to the shell plating were filled with a water-exclusion material; a small void between the torpedo bulkhead and a fuel tank was to be used for counterflooding. The maximum breadth of the water-exclusion layer was 1.98 meters. The largest compartment in the side protection system was that for the fuel oil, where a major portion of the energy of an explosion was to be dissipated; it reached a maximum width of 3.42 meters amidships. A void compartment was placed inboard of the fuel-oil wing tanks, just outboard of the torpedo bulkhead. The depth of the system at a distance of 3.5 meters below the design waterline varied from 4.12 meters at the forward armored bulkhead to 7.0 meters at amidships and 4.54 meters at the after armored bulkhead in the *Richelieu*. An additional space (a wireway and pipe tunnel) was located inboard of the torpedo bulkhead and extended the full length of the armored citadel. This could also be considered part of the side protection system, since the gas jet from an underwater explosion or splinters passing through the torpedo bulkhead would have to pass through it to gain access to the vitals. The torpedo or holding bulkhead was continuous throughout the system with no discontinuities. No accesses or cuts were permitted over its entire length. The supports for the piping and wiring had to be located at the top of the bulkhead or near the tank top so that the bulkhead could expand plastically or elastically over its center portion.

The longitudinal bulkhead that formed the inboard boundary for the outboard void compartment was a major structural component of the hull girder. This construction, first used in the *Dunkerque*-class battlecruisers, was repeated in the *Richelieu* design. The shell plating was only 10-mm thick, but it was reinforced by closely spaced shell stringers and intercostal longitudinals. This light plating was used to reduce the potential of splinters formed during a contact explosion. The torpedo bulkhead was constructed of 30-mm STS armor plate outside the propulsion plant. Outside Turret I and the secondary armament, where the protective layer began to diminish in breadth, the plating thickness was increased to 50 mm. The thickness was 40 mm in way of the diesel generator compartment and a machinery compartment aft. The system was designed to absorb the energy of an underwater explosion by the elastic and plastic deformation of structure and by the turbulence in the layers of air, water-exclusion material, and fuel oil. Ultimately if the explosive energy could not be completely contained in the layer itself, the flat torpedo bulkhead was designed to deflect between rigid top and bottom supports formed by the armor decks and the double bottom respectively.

TABLE 3-10

Characteristics of Side Protection System

<i>Location</i>	<i>Depth at 11.48' (3.5 m) below Design Waterline</i>	<i>Total Bulkhead Thickness</i>	<i>Torpedo Bulkhead Thickness</i>
Turret I	14.76' (4.50 m)	3.82" (97 mm)	1.97" (50 mm)
Turret II	19.19' (5.85 m)	3.43" (87 mm)	1.56" (40 mm)
Amidships	22.97' (7.00 m)	2.64" (77 mm)	1.18" (30 mm)

A possible weakness of this liquid-void scheme was the location of longitudinal bulkheads for the various spaces. The use of voids and liquids was effective, but the distances between the longitudinal bulkheads bounding the void areas were rather small. Under the intensive loadings resulting from a contact explosion at the side of the ship, the bulkheads might have touched during their deflections, permitting the transmission of the damage beyond the fuel space.

This condition was particularly serious in view of the fact that the Japanese Navy used torpedo charges as heavy as 680 kilograms compared to the 300-kilogram charge on which the French had based their design. The basic side protection system design had its only combat test at Mers el Kébir, when depth charges exploded near the *Dunkerque* and ripped open part of her side, but as all structural damage was confined to areas outboard of the torpedo bulkhead, French naval constructors considered this a vindication of their design.

When the *Jean Bart* was reconstructed at Brest after the war, the underwater hull form was modified to compensate for an anticipated overweight condition. Adding tear-shaped blisters also improved the side protection system. Blisters, 1.27 meters wide and approximately 122 meters long, were mostly underwater and as a result increased protection against contact explosions to approximately 500 kilograms of TNT. The shell of the ship was spaced farther from the torpedo bulkhead, ensuring that a torpedo or mine explosion would be kept at a greater distance from the vitals than in the *Richelieu*. This alteration also provided more material for the explosion to penetrate, as the outer plating was thicker than that in the *Richelieu*. In the *Jean Bart*, the torpedo bulkhead was 8.25 meters from the shell plating and 9.45 meters from the inboard bulkhead of the piping and wiring passage.

The water-exclusion material, "Ebonite Mousse," was used in the underwater protection system in way of the main-battery magazines and in the compartment just forward of the armored citadel. "Ebonite Mousse" was a dense rubber foam and gum with a specific gravity of 0.07-0.10. The material was encased in foil, which was arrayed around the periphery of the compartment to decrease the fire risk. Although this matter was inflammable, it was used because it was:

- light in weight
- nonpermeable to water even under a pressure of one atmosphere
- not subject to aging
- nonreactive to iron

With the vessel at a displacement of 40,900 metric tons, the wing fuel tanks empty, and either one or all of the unprotected compartments forward of the armored citadel flooded, the increase in draft of these battleships was such that there would still be freeboard at the bow (see Table 3-11). The use of water-exclusion material below the design waterline in the compartment immediately forward of the armor box reduced the potential flooding and improved the trim of the vessel if the compartment should be damaged. This material increased the protected portion of the ship, and thus the

TABLE 3-11

Summary of Effects of Water-Exclusion Material

Com- partments Flooded	Trim Change	GM	Height of Principal Deck above Waterline		Propeller Immersion
			at Perpen- dicular	at Armored Bhd.	
Forward of transverse armored bhd.	17.95 ft. (5.47 m)	9.84 ft. (3.0 m)	-0.98 ft. (-0.30 m)	3.61 ft. (1.10 m)	9.84 ft. (3.00 m)

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protected portion increased from 54.2 to 58.3 percent of the ship's length in the *Richelieu* and *Jean Bart*.

These ships were also provided with some underbottom protection to supplement the extensive side antitorpedo system: a double bottom 1.12-meters deep under the propulsion plant, and a triple bottom 2.50-meters deep under the main magazines with a top plate of 30-mm special treatment steel. French designers recognized the need to protect at least that part of the bottom under the main magazines, which could have been accomplished by providing armor protection or by installing a triple bottom. In any event, the designers doubted the advisability of allocating critical weight to bottom protection. It was impossible to design complete protection for the bottom structure against contact or noncontact explosions, because it would have increased the ship's depth and ultimately the standard displacement beyond design and treaty limits.

There would have been difficulty in arranging the machinery and magazines if it became necessary to sacrifice as much as 4.6 meters of height above the bottom plating. Most resistance against a powerful, distant explosion—such as a magnetic mine—would have been provided by the ship's structure, which mattered more than just concentrating the protection. Therefore, the bottom structure was fabricated of high tensile steel (HTS). The double bottom itself was not much deeper than in most merchant ships.

Table 3-12 summarizes the penetration ranges of armor plate against various types of shells. These figures were based upon a formula derived by Jacob De Marre, and reflect major armor thicknesses developed for design PN 196, the preliminary of the final *Richelieu* design. They do not account for near misses or the effects of interior armor. French naval constructors believed that no fragments or shells could reach the vitals of these ships, since they would have to pass through the 50-mm sloped portion of the lower armor deck. In addition, these fragments or shells would have to pass through the torpedo protection system, with its wing tanks filled with either fuel-oil or salt-water ballast. Furthermore, this system had a transverse depth of 4.35 meters, water-exclusion material adjacent to the torpedo bulkhead in way of the main-battery magazines and along the shell throughout the system, and a thickness ranging from 30 mm to 50 mm. All this provided an equivalent protection of 80 mm of steel. The liquid-filled portions of the side protection system were particularly efficient in slowing down shells with underwater trajectories which struck below the main side belt.

Stability and subdivision. The *Richelieu*-class battleships had excellent subdivision, and no watertight doors were permitted in major transverse bulkheads below the damage-control deck. All accesses to lower decks were achieved through trunks. No penetrations were permitted in the longitudinal bulkheads. The Service Technique des Constructions conducted a thorough damage stability analysis similar to that

TABLE 3-12

Armor Penetration Data*Design PN 196**Penetration Ranges—Vertical*

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	5.1" (130 mm) MK 1932 V (fps) = 2,625 (800 m/s)	6.0" (152 mm) MK 1930 V (fps) = 2,854 (870 m/s)	8.0" (203 mm) MK 1924 V (fps) = 2,789 (850 m/s)
Side belt of 13.39" (340 mm) Sloped at 15.4°	P.A.	P.A.	P.A.
380-mm turrets Face plate 16.54" (420 mm) Sloped 17°	P.A.	P.A.	P.A.
Main barbettes 14.41" + 0.67 + 0.67 (366 mm + 17 + 17)	P.A.	P.A.	P.A.
Conning tower 13.78" + 0.67 + 0.67 (350 mm + 17 + 17)	P.A.	P.A.	P.A.
152-mm turrets Face plate 4.53" (115 mm) Sloped at 25°	6,340 (5,800)	14,545 (13,300)	31,170 (28,500)
Barbette—152 mm 3.94" (100 mm)	7,929 (7,250)	15,201 (13,900)	27,340 (25,000)
Armor deck over magazines 6.69" (170) Class B armor	P.A.	P.A.	P.A.
Armor deck over machinery 5.91" (150)	P.A.	P.A.	P.A.
Top of conning tower 6.69" + 0.67 + 0.67 (170 mm + 17 + 17)	P.A.	P.A.	P.A.
Platform deck 3.94" (100)	P.A.	P.A.	30,512 (27,900)
Top of 152-mm turrets 2.76" (70)	P.A.	26,465 (24,200)	26,301 (24,050)
Top of 380-mm turrets 6.69" (170) Class A armor	P.A.	P.A.	P.A.

P.A. = Protection Assured at All Distances

11" (280 mm) German V (fps) = 2,805 (855 m/s)	13" (330 mm) MK 1931 V (fps) = 2,805 (855 m/s)	14" (355.6 mm) V (fps) = 2,756 (840 m/s)	15" (380 mm) MK 1935 V (fps) = 2,707 (825 m/s)	16" (406 mm) Nelson V (fps) = 2,625 (800 m/s)
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9,300 (8,500)	16,510 (15,100)	18,480 (16,900)	20,560 (18,800)	23,510 (21,500)
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5,800 (5,300)	13,780 (12,600)	16,400 (15,000)	19,410 (17,750)	24,610 (22,500)
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9,460 (8,650)	17,280 (15,800)	20,010 (18,300)	22,530 (20,600)	27,395 (25,050)
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10,500 (9,600)	18,700 (17,100)	21,490 (19,650)	24,170 (22,100)	29,360 (26,850)
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Penetration At All Ranges

Penetration At All Ranges

36,310 (33,200)	36,745 (33,600)	34,670 (31,700)	32,590 (29,800)	32,370 (29,600)
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34,230 (31,300)	34,560 (31,600)	32,480 (29,700)	30,460 (27,850)	30,290 (27,700)
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40,135 (36,700)	40,790 (37,300)	38,600 (35,300)	36,745 (33,600)	36,530 (33,400)
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28,870 (26,400)	28,270 (25,850)	26,410 (24,150)	24,720 (22,600)	24,060 (22,000)
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24,220 (22,150)	22,970 (21,000)	22,040 (20,150)	20,560 (18,800)	19,410 (17,750)
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40,260 (36,600)	40,680 (37,200)	38,495 (35,200)	36,640 (33,500)	36,200 (33,100)
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done in U.S. battleships. As a result, the required metacentric heights (GM) were well established early in the vessel's preliminary design. Although the metacentric heights were not as large as those in the *Bismark* or *Yamato*-class battleships, they still yielded sufficient righting arms to produce a good range of stability. These ships had a range of stability of some 65 degrees, with a reserve buoyancy of 44,295 metric tons. The use of water-exclusion material and compartmentation reduced the dangers of flooding, thus large metacentric heights and wide beams were unnecessary. The *Richelieu*, after her 1943 New York overhaul, had the stability characteristics tabulated in Table 3-13.

TABLE 3-13
Stability Data

Condition	Displacement	Metacentric Height
Light	37,674 tons (38,279 mt)	6.16' (1.88 m)
Without ammunition	39,478 tons (40,112 mt)	6.47' (1.97 m)
Normal	42,609 tons (43,291 mt)	7.35' (2.24 m)
Full load	46,797 tons (47,547 mt)	9.28' (2.83 m)

Radar. Although radar was not specified in the original design, it was installed on the *Richelieu* and *Jean Bart* before the Allied invasion of North Africa in 1942. The *Richelieu* was equipped with a Sadir M. E. 140 transmitter and M. E. 126 receiver, and a display screen by Compagnie des Compteurs; it could detect aircraft at a range of 30 kilometers. The *Jean Bart*, in the summer of 1942, received a 2-meter Sadir radar that could detect aircraft at an altitude of 762 meters at a range of 50 to 70 kilometers.

While the *Richelieu* was undergoing conversion in the United States (1943) and was attached to the Home Fleet (1944), she was equipped with more sophisticated radar gear. This equipment was maintained after World War II, and in April 1951 consisted of the radar gear tabulated in Table 3-14. The *Jean Bart* benefited from French radar research more than the *Richelieu*, and when reconstruction was completed in 1949, sixteen sets of French design and manufacture were installed, including navigational radar and more sophisticated fire-control radar for her larger and more complex antiaircraft battery, especially the 100-mm and 57-mm guns.

The new air- and surface-search radars were more complex than those installed on previous French warships and were also capable of detecting very small targets at extreme ranges. Such equipment required much space for their display units, receivers, cable, and wave-guides. This was also true for radio and other telecommunication and intercommunication equipment. Space had to be found in the command tower for

TABLE 3-14
Summary of Radar Equipment—Richelieu

SG-1(US)—Surface search with a range of 25 nautical miles
 SF(US)—Radar with a 15-mile range
 281B(UK)—Aerial Surveillance, 60 to 80-mile range
 DRBC10A*—Radar for the 380-mm guns (1 set)
 285P(UK)—Radar for the 152-mm guns (2 sets)
 SA2(US)—Gunfire-control radar located on top of the mast stack.
 It had a range of 40 miles.

* French radar set

a combat information center which judged, combined, or divided the information which came to it into a complete picture of the tactical air and surface combat situation, thereby effecting prompt action or reaction by the ship's command.

Propulsion Plant. As early as 1929, there was a conviction within the French Navy that new battleships should have high speed. The *Dunkerque* design proved that such speeds were possible without intolerable reductions in offensive and defensive characteristics. Furthermore, large shaft horsepower could be concentrated in rather constricted spaces provided that the propulsion plant was sufficiently protected.

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The Technical Board required that the *Richelieu*-class ships should make 29.5 knots with the normal rating of 150,000 metric horsepower. To meet this requirement, the ships were initially designed to use six boilers of the type used on the *Mogador*-class destroyers. Because of the overweight problem, however, the Conseil Supérieur decided to use the Sural*-Indret (Norguet) boilers, a new type unlike other boilers in previous French warships. In studies of reduction of boiler volume and weight, it was determined that combustion under pressure would help use the velocity and pressure of the flue gases. Also, it was recognized that height and space were limited in these ships. Thus, the depth of a ship's hull restricts the efficient use of the flue-gas heat. Shore power plants make better use of the heat, but have enormous boilers. The new type boilers made use of flue gases at the exit of the tube nests to preheat the incoming air, and combustion was under pressure. The increased velocity of the flue gases that resulted must have caused a better exhaust of combustion by-products—a desirable feature—and thus meant better fuel economy. These measures made it possible to decrease boiler size and increase thermal efficiency. Steam was supplied to the turbines at 29.71 kilograms per square centimeter, superheated to 371 degrees centigrade.

The boilers operated under a furnace pressure of two atmospheres. Flue-gas velocity was increased by the use of two "Rateau"-type blowers per boiler driven at 4,000 to 5,000 rpm by a turbine using boiler-combustion gases. The increase in the rate of heat exchange permitted reduced boiler volume, and the size of the firerooms was reduced by 30 percent. This also reduced fireroom congestion and vulnerability.

The Sural-Indret (Norguet) boilers had an upper drum of relatively large diameter and a lower one half that size. They were in the same vertical plane and were connected by a number of curved tubes. A large downcomer was positioned between the two drums outside the combustion chamber. The boilers had a cylindrical shape due to the curved downcomer tubes.

As the blowers operated with fairly high exhaust temperatures, an economizer was added to the heat cycle to increase overall efficiency. The usual method of preheating the air was not used, as compression in the turboblowers raised the air temperature from 121 to 138 degrees centigrade. The blowers were operated by an auxiliary steam turbine shaft after the boilers were lighted off, until sufficient shaft horsepower had been developed. This process produced 82 percent thermal efficiency, in contrast to the 74 percent of more conventional systems.

Funnel design was given special attention. The merits of a central fixed funnel and a swivel-type stack were evaluated during the preliminary design. The swivel funnel was given serious consideration, since it would allow the stack gases to be exhausted

* Sural—"suralimentation" or supercharging

away from the ship in a manner that would not interfere with the main or secondary battery rangefinding. Such a device was prompted by an analysis of the Battle of Jutland, where both British and German ships had their vision of the target hampered by their own smoke. The concept had to be abandoned finally, since the mechanism became overly complex, there was a high risk of failure, and the overweight problem in the *Richelieu* battleships had become acute. Following exhaustive tests conducted to ensure that flue gas was carried clear of the guns and directors in the area of possible downwash, the funnel was trunked aft of the mainmast—one of the most striking exterior features of these ships. Its forward portion was fitted with an air intake to blow fumes high and clear of the superstructure. Velocity was added by the venturi effect of ducting flue gas through small apertures into the lower portion of the funnel fairings. Soot blowers were not required because flue gas exited at very high velocity from a small stack pipe. In both ships the revised arrangement was a success.

Boilers and turbines were located in four watertight compartments with three boilers in each fireroom and two turbines in each engine room. The compartments had no longitudinal bulkheads, thus preventing any off-center flooding. Three boilers and two turbines powered two shafts, an indication of the concentration within the engineering plant. The firerooms were designed so that either one could supply steam to both engine rooms. In the *Gasconne* the propulsion plant was shifted farther forward.

Since speed was an important objective in the design of the *Richelieu* battleships, exhaustive model tests were undertaken at the Paris Model Basin to determine the optimum draft, beam, and length. Eight different models were tested. The results are tabulated in Table 3-15.

TABLE 3-15

Propulsion Data—Model Tests

Speed	Power necessary at the normal displacement of 40,243 tons (40,900 mt) with 2,853 tons (2,900 mt) of fuel oil	Power necessary at the full-load displacement of 44,277 tons (45,000 mt) with 6,199 tons (6,300 mt) of fuel oil	Propulsive coefficient
15	13,020 (13,200)	13,515 (13,700)	0.44
18	21,995 (22,300)	23,080 (23,400)	0.45
22	40,440 (41,000)	42,410 (43,000)	0.46
26	71,015 (72,000)	72,990 (74,000)	0.495
29	105,540 (107,000)	116,385 (118,000)	0.50
30	119,345 (121,000)	133,155 (135,000)	0.50
31	138,085 (140,000)	151,695 (153,800)	0.50
32	162,745 (165,000)	177,540 (180,000)	0.50
33	191,345 (194,000)	209,100 (212,000)	0.50

The desire for adequate maximum speed was realized during very brief builder's trials in June 1940 when the *Richelieu* made 32.6 knots on an overload power of 178,000 metric horsepower and 31.9 knots with the maximum power of 157,000, at a displacement of 43,500 tons. The speed was reduced to 31.6 knots after alterations at the New York Navy Yard increased the draft and displacement. Between November 1951 and February 1952, the *Richelieu* conducted various sea trials (see Table 3-16).

The waterline length of 242 meters, combined with a fine hull form (prismatic coefficient = 0.58) gave excellent speed performance, with very good resistance factors at high speeds. This was mandatory in order to obtain the desired operational characteristics. The ships had an excellent combination of speed, protection, and armament. Endurance was adequate, as shown in Table 3-17.

TABLE 3-16

Trial Data—Richelieu

Displacement		Speed (knots)	Horsepower		Fuel consumption			
Long tons	Metric tons		English	Metric	T/Hour		T/mile	
					English	Metric	English	Metric
40,461	41,110	17.85	25,402	25,755	11.6	11.8	0.65	0.66
40,783	41,437	17.10	25,284	25,635	12.6	12.8	0.74	0.75
41,182	41,843	26.35	81,963	83,100	—	—	—	—
41,244	41,906	30.38	135,284	137,160	43.5	44.2	1.44	1.46
41,392	42,056	30.31	132,798	134,640	—	—	—	—
42,786	43,473	22.71	45,489	46,120	17.5	17.8	0.77	0.78
42,826	43,513	18.42	21,995	22,300	10.9	11.1	0.59	0.60
Fuel consumption		Propulsion efficiency						
Lbs/SHP/Hr	Kg/MHP/Hr							
1.01	0.46	0.37						
1.10	0.50	0.33						
—	—	0.45						
0.71	0.32	0.48						
—	—	0.49						
0.86	0.39	0.47						
1.10	0.50	0.50						

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The fuel-oil capacity of the *Richelieu* was later increased to 6,905 metric tons by using the trim tanks as bunkering spaces. The *Jean Bart*, with a fuel capacity of 6,805 metric tons, had less endurance—8,000 miles at 14 knots, 6,900 miles at 20 knots, and only 3,400 miles at 30 knots in the same conditions. French naval constructors thought that the use of trim tanks for fuel stowage might impair the possibilities for counterflooding.

There were four propellers with 4.81-meter diameters. It was necessary to decrease the propeller rpm from 270 in the *Dunkerque* to 230 rpm in the *Richelieu* so that the propulsive coefficient would be as satisfactory as possible. Two shafts on each side of the hull were supported by a single strut. The large semibalanced centerline rudder had a maximum hard-over angle of 32 degrees. This centerline location was a serious shortcoming, because the rudder was not in the propeller race, hence it was less efficient and resulted in a larger turning radius than with a comparable twin-rudder installation.

Electric plant. The electrical load was greater than in any previous French battleship, since the capstan/windlass, steering gear, cranes, ventilation, refrigerating equipment, hoists, elevators, galley and pantry equipment, the main and secondary turrets, and parts of the heating system were dependent on electrical power. Two turbogenerators powered four 750-kw units, each turbine being coupled to two generators to develop

TABLE 3-17

Endurance Characteristics—Richelieu

Speed in Knots	15	20	25	29	30
Temperate conditions—clean hull	—	7,750	4,800	—	3,300
Tropical conditions—clean hull	8,250	6,750	4,750	3,400*	—
Tropical conditions—foul hull	—	5,600	3,800	**	—

* Maximum speed in tropical waters. The higher water temperatures in the tropics reduce the efficiency and power of steam turbine plants by decreasing the vacuum at the main condenser.

** Speed not attained in tropical waters with a foul bottom. Bottom fouling becomes a serious problem much more rapidly in tropic waters.

1500 kw. Three diesels powered six generators (two generators on a common shaft) and two 150-kw generators supplied the emergency power. A total of 9300 kw could be generated in a *Richelieu*-class battleship. The electrical system was primarily direct current, but some alternating current was available for the armament requiring it. The basic current was 230 volts, but the generator arrangement permitted the production of 460 volts for use in the 380-mm turret power supply.

The electric plant was divided into four stations, one for emergency power. The main electrical generating stations were located in sections O (abaft the after engine room), L (the forward engine room), and H (diesel generator room between the two forward turrets). Each station was autonomous and could handle the normal ship electric current of 230 volts or the special 460 voltage for the 380-mm turrets. The three stations could produce the normal ship current, but could not simultaneously provide the larger 460-volt current, since the generation of the latter current required a special hook-up of the generators in series. While the ship was in combat, two electrical stations would be in operation with one on standby. The emergency diesel generating station was located on the main deck and was capable of providing only 230-volt current.

The dependence of these battleships on electrical power necessitated some duplication of their electrical circuits in case of battle damage. Port and starboard wire tunnels extended the full length of the armored citadel and contained the cabling for each deck. This cable was independent of that of decks above or below and on the opposite side. All cabling penetrations in the bulkheads were watertight. A third wire tunnel in the double bottom provided a third circuit in case both wing wire tunnels were damaged. A separate circuit was also provided for those areas above the upper armor deck. Emergency circuits from switchboards in watertight compartment O were provided for the lighting and the other important auxiliary and boiler feed systems.

Hull Characteristics. The structural analysis of the *Richelieu*-class battleships was extensive and the most elaborate performed on a battleship of that period. The strength was based on a wave-height to ship-length ratio of 0.05 (ship length/20); however, different wave crest positions, as well as wave lengths, were tried to determine the maximum bending moment. The main deck was the strength deck for the strength calculations, and the longitudinal bulkhead just inboard of the side plating served as a major component of the hull girder along the length of the side protection system.

Seakeeping was an important consideration in the design of these ships, and high freeboard with adequate flare at the bows was sought from the earliest phase of design. Based upon seakeeping considerations, the height between the upper and main decks was rather large and greater than in most other ships of their time. Seakeeping tests at the Paris Model Basin confirmed that the freeboard forward would be sufficient in rough weather to keep the gun platform free of green seas. The rolling period of 13.5 seconds was the result of a need for high metacentric heights for damage considerations, and was a little greater than the rolling periods of the *Nelson* and *Baden*. The pitching period was calculated to be 4.77 seconds, which was relatively small, but together with the good flare forward it produced good seakeeping performance.

Welding. Welding, a rather new concept in warship construction prior to World War II, was used extensively in these ships. In the *Richelieu*, some of the joints of plates and longitudinals, all the plating and supports of all the platforms and decks (with the

exception of the strength and armored decks), the external border of the armor belt, and all transverse and longitudinal bulkheads in the protective layer were welded. In succeeding vessels of the class the amount of welding increased, with a significant reduction in hull weight and fabrication time. In the *Clemenceau*, welding was to be used more extensively, particularly in the seams and supports of the strength deck. The *Gasconne* would probably have been approximately 95 percent welded. The *Jean Bart*, during postwar reconstruction, benefited from improved welding methods. Whenever a main structural component had to be replaced, it was welded. Most of the shell and deck seams, and the longitudinal connections to the side and deck plating, were welded.

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Displacement. In 1937, treaty limitations on battleship standard displacement were raised to 45,000 tons, permitting greater latitude in improving the armor protection, structural features, and main armament. Modifications made during the construction of the *Richelieu* increased standard displacement to approximately 37,100 metric tons. Among the changes and additions were the following:

- accommodations for a larger complement
- raising the upper deck and increasing the freeboard
- reinforcing bow structure forward of the armor box
- degaussing equipment
- additional breakwater forward of Turret I
- replacement of swiveling funnel by fixed mast stack
- two 37-mm gun mounts added each side of the hangar
- expansion ducts installed through armor decks above powder magazines
- two forward 152-mm triple turrets replaced by six 100-mm twin mounts

Only the changes in the funnel and the secondary armament saved weight, but some weight reduction was achieved by extending the use of welding. In 1943, the *Richelieu* was overhauled and modernized with a weight increase estimated to be more than 1,200 metric tons. This resulted from added 40-mm and 20-mm gun mounts, new magazines for their ammunition, newer radar equipment, and accommodations for a much larger complement to handle the expanded functions. Items removed were aircraft and catapults, hangar, crane, aircraft fuel and ammunition, and the 37-mm gun director atop the forward command tower. Fuel-oil capacity was increased by some 500 tons to improve endurance. Increased displacement put the lower armor deck below the water—a critical situation in case of damage.

Evaluation. The *Richelieu*-class battleships were the only “35,000 tonners” completed by France. Although their well-balanced design had certain shortcomings, most of them were eliminated in the wartime modernization of the *Richelieu* and the postwar reconstruction of the *Jean Bart*. Inadequate horizontal protection over the secondary magazines was not corrected in either of these ships, but was improved in the *Gasconne*. The main-battery disposition was only a minor weakness, which was once again eliminated in the redesign of the *Gasconne*.

The *Richelieu*-class battleships exhibited many bold, even revolutionary, design concepts, including:

- Concentration of the propulsion plant and main armament

- Propulsion plant arrangement in four large compartments, two for all turbines and two for all boilers
- High-angle mountings of the 152-mm triple turrets, giving them dual-purpose capabilities
- Flooding control through the use of water-exclusion material in large void compartments
- Side fuel-oil tanks designed to permit rapid flooding
- Forced-combustion boilers

The technical concept to which the ships were built necessitated the concentration of the main armament, but later the French Navy questioned the wisdom of limiting the firing arcs of the main-battery guns and leaving little room for the placement of an antiaircraft battery. Therefore, the *Gascogne* was given a more conventional fore-and-aft turret arrangement. Although the after turret could not fire directly astern in the *Richelieu*, *Jean Bart*, and *Clemenceau*, it had an arc of fire of 312 degrees. This left only an arc of 48 degrees not covered by the main battery, which was not considered a serious weakness by the French; the firing arcs of the individual turrets were greater than those of most battleships designed prior to World War II. (The *Dunkerque* experience at Mers el Kébir proved the weakness of this heavy-gun arrangement.)

Inadequate deck armor over the secondary gun magazines and protection for their ammunition hoists was demonstrated by damage from a 406-mm shell fired by the *Massachusetts* during the naval battle of Casablanca. The thickness of the hoist protection was only 100 mm, compared to 150-mm deck armor at the same position. The *Gascogne*'s horizontal protection offered a better solution in shielding the main magazines, but in that design the main turrets were fore and aft.

The underwater protection was one of the deepest systems in modern battleship design. The transverse arrangement of compartments and the depth of the system was the same as in the *Dunkerque* and *Strasbourg*, and basically followed the "caisson blindé" theory advocated by the late nineteenth century French naval constructor, Émile Bertin. The arrangement in later French battleships had been modified, however, and included deck slopes. Designed to repel 300-kilogram TNT charges (500 kilograms in the modified *Jean Bart*), with adequate margins, the system was never tested in combat. With breadths of 7 meters in the *Richelieu* and 8.3 meters in the *Jean Bart*, it indeed was substantial.

The secondary armament was a dual-purpose type, even though 152-mm guns were rather cumbersome for use against high-speed targets. The guns were designed simply for barrage fire. When the design of the *Richelieu*-class battleships began, French naval constructors expressed the opinion that separate surface-and-air gun defense was not possible in 1934. The original scheme was to place 152-mm guns in excellent positions on the beam and at the after end of the superstructure; this was modified in 1939 due to convictions that the antiaircraft battery was insufficient and that there would be production problems in their manufacture. Two 152-mm triple turrets were replaced by 100-mm guns of an older model to augment this defense. Later, the *Richelieu* was equipped with Oerlikon and Bofors machine guns to reinforce the air defense. The French Navy was not satisfied with these solutions, however, when it began reconstruction and modernization of the *Jean Bart*.

The battleship era, typified by the *Richelieu* and *Jean Bart*, ended with the completion of the latter in 1949. Designed during a period of increasing awareness of the threat of air attack, her completion was so delayed that her final characteristics were markedly affected by the impact of air power on naval warfare. The completion of the *Jean Bart*, the last in the long line of battleships which began with the HMS *Dreadnought* in 1906, marked a fitting close to their era.

Battleship Projects, 1940—Alsace Class. Early in 1940 the French Navy began studies for the new *Alsace*-class battleships. The decision to design a new battleship class was decided by the Conseil Supérieur, since the construction of the *Bismarck* and *Tirpitz* was well advanced, the Germans projected six more battleships of the H class, and Italy had begun the construction of two more *Vittorio Veneto*-class battleships. These ships were to be more heavily armed and protected than the *Richelieu* or *Gascogne* variants. Three standard displacements were considered, the 40,000 tons being that proposed by Great Britain for her *Lion* class, 45,000 tons being the upper limit as prescribed by the 1936 London Treaty, and the 42,500 tons being a compromise and the minimum displacement to fit an adequate 406-mm battery with a 30-knot speed. It was further determined that with the protection being sought, a 30-knot minimum speed, and a conventional arrangement of the main battery, the number of guns in the main armament would be as tabulated in Table 3-18.

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TABLE 3-18

Conceptual Design Characteristics—*Alsace* Class

<i>Displacement</i>	<i>Main Battery</i>
40,000 tons (40,640 mt)	nine 15" (380 mm) 2 triple turrets forward, 1 aft
42,500 tons (43,180 mt)	nine 16" (406 mm) 2 triple turrets forward, 1 aft
45,000 tons (43,710 mt)	twelve 15" (280 mm) 2 quadruple turrets forward, 1 aft

It seems reasonable to expect that the *Alsace* class would have exhibited the following:

- Armor protection—similar to the *Richelieu* class with the minimum thickness equivalent to that used in the *Gascogne*.
- Speed would have been at least 30 knots. The new French battlefleet consisting of cruisers, destroyers, aircraft carriers, battlecruisers, and battleships featured speeds in excess of 30 knots.
- The secondary armament and antiaircraft armament would have been similar to that of the *Gascogne*.

Although the French Navy never decided which of the three variants in Table 3-18 it would design the new *Alsace* class to, there is enough data available for the authors to project what the characteristics of these new battleships might have been. The construction time of any battleship was determined by the design and production of its main-battery guns, turrets, and associated machinery. The 40,000 and 42,500-ton standard displacement ships featured triple turrets. The loading and elevating mechanisms of triple turrets would have to be designed and tested while France was at war. This would have been a developmental challenge, since France had never built a triple turret mounting guns of such large caliber. It would appear logical that a quadruple turret arrangement would have been chosen since it would result in a shorter construction period and permit more changes to the original *Richelieu* design. These alterations would have been to the protection, particularly the main side belt and armored bulkheads which had been reduced in the *Richelieu* class because of the overweight problem. Based on these considerations and the fact that the hull form would have been similar to the *Dunkerque*- and *Richelieu*-class capital ships, the *Alsace* class might have had the characteristics summarized in Table 3-19.

The additional 380-mm turret and increased shaft horsepower to maintain a 30-knot speed would have resulted in a larger ship than the *Richelieu* class. A greater

TABLE 3-19

The Alsace-Class 45,000-ton Battleship (Estimated)

Standard displacement	45,000 tons (45,714 mt)
Full-load displacement	55,125 tons (56,000 mt)
Waterline length	886' (270 m)
Waterline beam	116.5' (35.5 m)
Draft, design	30.24' (9.25 m)
Armament	Twelve 15" (380 mm)/45-caliber guns in three quadruple turrets. Twelve 6" (152 mm)/55-caliber guns in four triple turrets. Twelve 3.94"/45-caliber guns in four twin turrets. Eighteen 1.46" (37-mm) guns. One floatplane, one catapult
Speed	At least 30 knots
Shaft horsepower	197,200 (200,000 mhp)
Armor	Main side belt—12.6"-14.17" (320-360 mm) sloped at 15.5 degrees. Decks—6.69" (170 mm)—magazines —5.91" (150 mm)—machinery

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length would have increased the deck area for additional anti-aircraft guns. In fact, the 152-mm guns would have been grouped with other lighter weapons to provide a barrage defense—a popular concept among European powers during this period. The beam would have been widened, probably to 35.5 meters, which was the beam of the reconstructed *Jean Bart*. The fact that even the *Richelieu* or *Jean Bart* were unable to transit the Panama Canal indicates that the beam of the *Alsace* class would have resulted from French drydock limitations. It is difficult to project armor thicknesses as they would have been somewhat influenced by the displacement. It is reasonable to assume, however, that these French battleships might have featured greater armor thicknesses than the *Gascogne*. The French Navy was seriously considering their construction, and names were selected, when the Parlement approved their construction on 15 April 1940. They were the *Alsace*, *Normandie*, *Flandre*, and *Bourgogne*. Two other unnamed ships were also contemplated.

Name	<i>Richelieu</i>	<i>Jean Bart</i>
Builder	Brest Navy Yard (Hull No. B61)	Chantier de la Loire and Chantier de St. Nazaire-Penhoët
Laid down	22 October 1935	12 December 1936
Launched	17 January 1939	6 March 1940
Operational	15 June 1940	16 January 1949
Reconstructed	1943 (New York Navy Yard)	1946-50 (Brest Navy Yard)
Disposition	Scrapped at Cantiera Navali Santa Maria—Genoa, August 1968.	Sold for scrap in January 1970.

Name	<i>Clemenceau</i>	<i>Gascogne</i>
Builder	Brest Navy Yard (Hull No. B62)	Chantier de la Loire, St. Nazaire
Laid Down	17 January 1939	. . .
Launched	March 1941	. . .
Operational	. . .	. . .
Disposition	Bombed and sunk by Allied aircraft on 27 August 1944 at Landevennec.	Canceled on 24 June 1940.

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Displacement

Richelieu

47,721 tons (48,500 mt) Full load—battle
42,875 tons (43,575 mt) Normal (approx. ½ fuel)
40,270 tons (40,928 mt) Design

Jean Bart

48,950 tons (49,736 mt) Full load
42,806 tons (43,493 mt) Light

Dimensions

<i>Richelieu</i>	813'2" (247.85 m) Length overall
<i>Clemenceau</i>	793'12" (242.00 m) Waterline length
<i>Gascogne</i>	108'6" (33.08 m) Beam—maximum
	51'2" (15.60 m) Depth to upper deck
	30'1" (9.17 m) Design draft
	31'7" (9.63 m) Draft at 43,293 tons (43,988 mt)
<i>Jean Bart</i>	813'2" (247.85 m) Length overall
	793'12" (242.00 m) Waterline length
	109'5.382" (33.36 m) Beam at main deck
	116'7.208" (35.54 m) Beam over bulges
	51'2.171" (15.60 m) Depth to upper deck

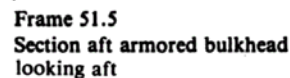
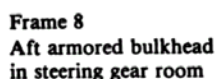
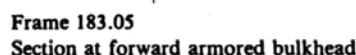
Hull characteristics at designed draft—*Richelieu*

Displacement	40,270 (40,928 mt)
Draft	30'1" (9.18 m)
Freeboard	
fwd	30'7.322" (9.33 m)
aft	21'7.054" (6.58 m)
Depth (amidships)	58'8.722" (17.90 m)
Block coefficient	0.541 Midship coefficient 0.94
Prismatic	0.576 Waterplane coefficient 0.65

Hydrostatic data

Draft	Displacement
30.12' (9.17 m)	40,270 tons (40,928 mt)
33.18' (10.113 m)	45,236 tons (45,975 mt)
36.19' (11.030 m)	50,069 tons (50,887 mt)

**Gascogne* (320 + 18)
Richelieu — 1935 (340 + 18)



Richelieu, Jean Bart, Gascogne, Clemenceau
eight 15"/45-caliber (Mark 1935) (380 mm)
nine* 6"/55-caliber (Mark 1936) (152 mm)

Antiaircraft	100 mm	57 mm	40 mm	37 mm	20 mm	13.2 mm
<i>Richelieu</i> (1945)	12	none	69	none	41	none
<i>Jean Bart</i> (1952)	24	28	none	none	20	none
<i>Clemenceau</i>	12	none	none	8	none	32
<i>Gascogne</i>	16	none	none	20	none	36

Gascogne; 2 Loire-Nieuport 130 seaplanes, 1 catapult
Richelieu, Jean Bart; 3 seaplanes as above, 2 catapults, all deleted during reconstruction.
Clemenceau; None

Immunity zone 20,560 to 32,590 yards (18,800 to 29,800 m) vs. 380-mm/45-caliber gun (Richelieu, Jean Bart, Clemenceau)

Richelieu, Jean Bart, Clemenceau: 12.99" (330 mm) at 15.5°
Gasconne: 12.60" (320 mm) at 15.5°

Deck Armor	<i>Centerline</i>
Main deck	5.90" (150 mm)
Second deck	1.57" (40 mm)
	<u>7.47" (190 mm)</u>

The diagram illustrates the internal structure of the USS Arizona's hull, showing the arrangement of various compartments and structural elements. Key features include:

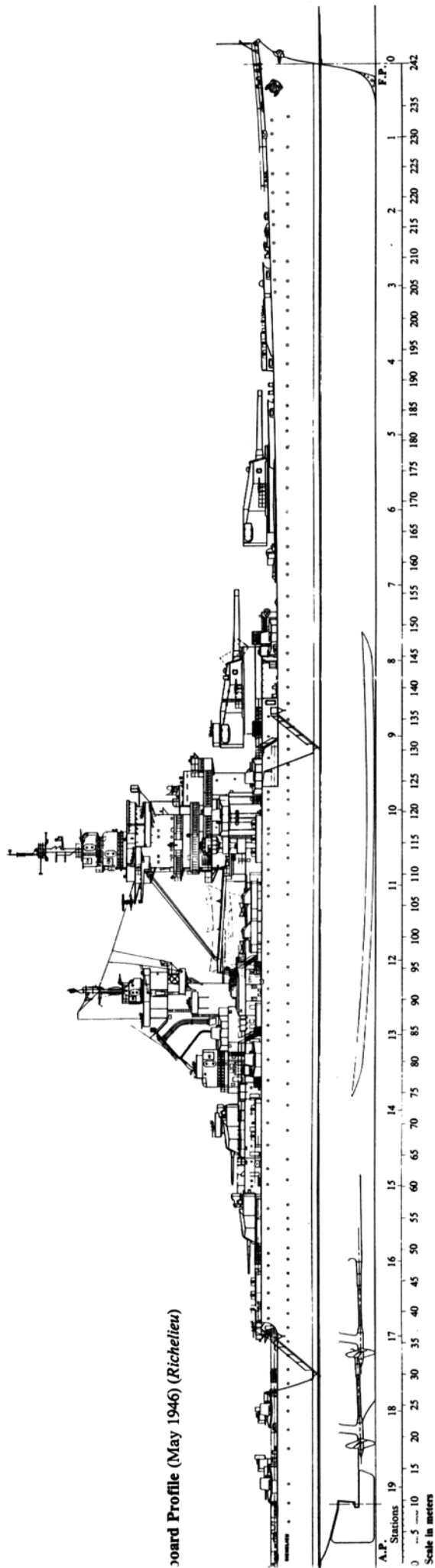
- Wire way:** A horizontal passage for cables, labeled "wire way".
- Voids:** Several empty spaces within the hull structure, labeled "void".
- Fuel oil:** Compartments for fuel storage, labeled "fuel oil".
- Water exclusion material (Bourrage):** Material used to prevent water from entering the hull, labeled "water exclusion material (Bourrage)".
- Dimensions:** Various measurements are provided, including a depth of 330 and a width of 18.17 meters (DWL).
- Structural Components:** The diagram shows the hull plating, internal bulkheads, and other structural elements.

Midship Section — *Richelieu*

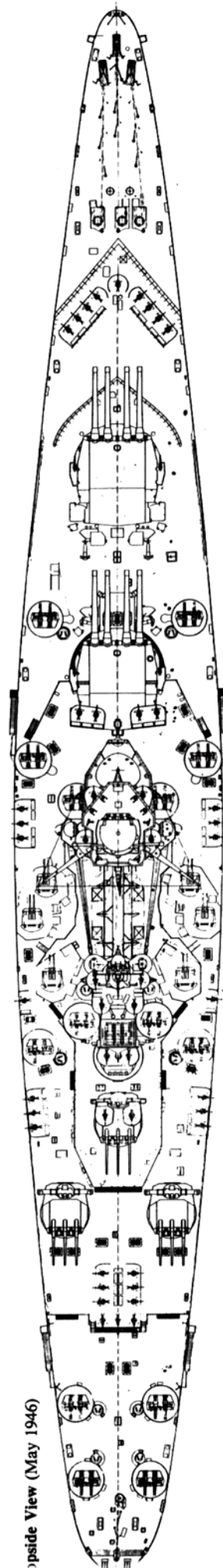
Side protective
system depth

27.13' (8.27 m)—*Jean Bart* (with bulges)
22.97' (7.00 m)—*Richelieu*

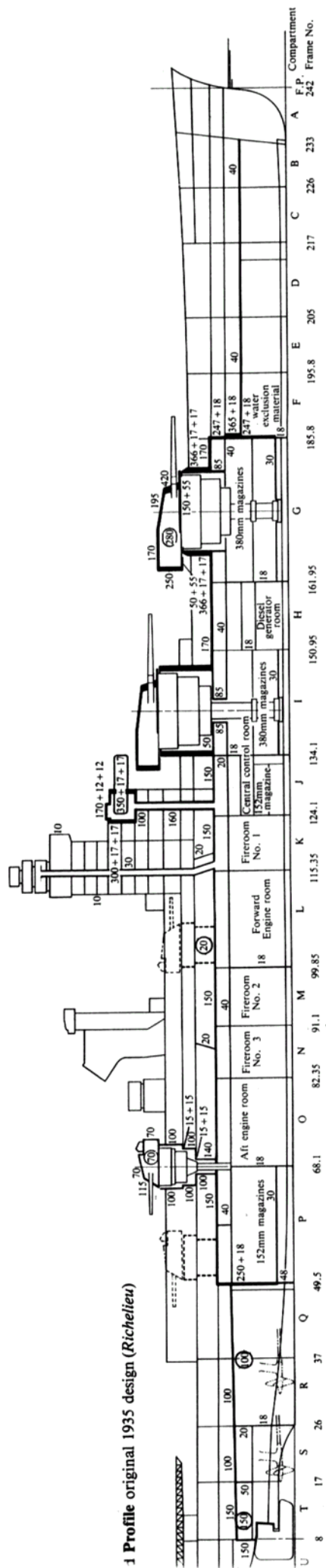
Board Profile (May 1946) (Richelieu)



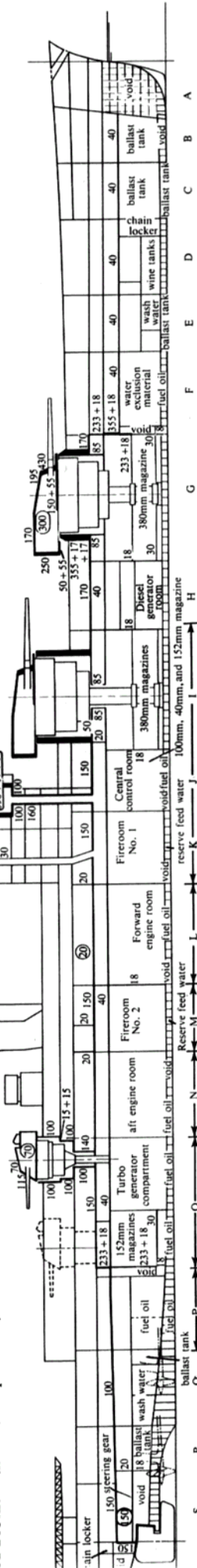
Inside View (May 1946)



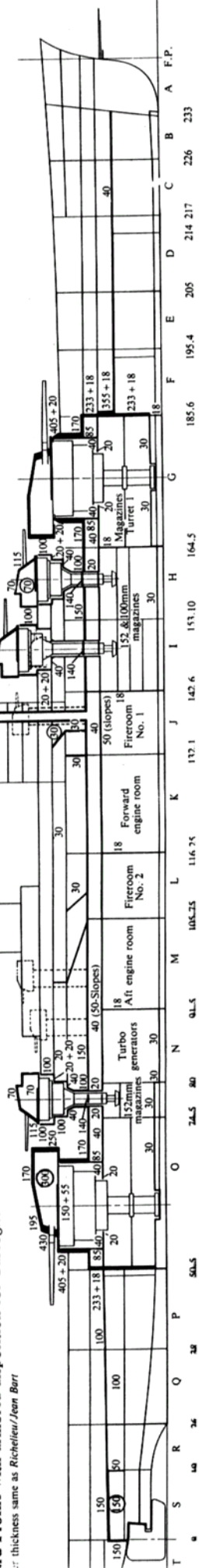
1 Profile original 1935 design (Richelieu)



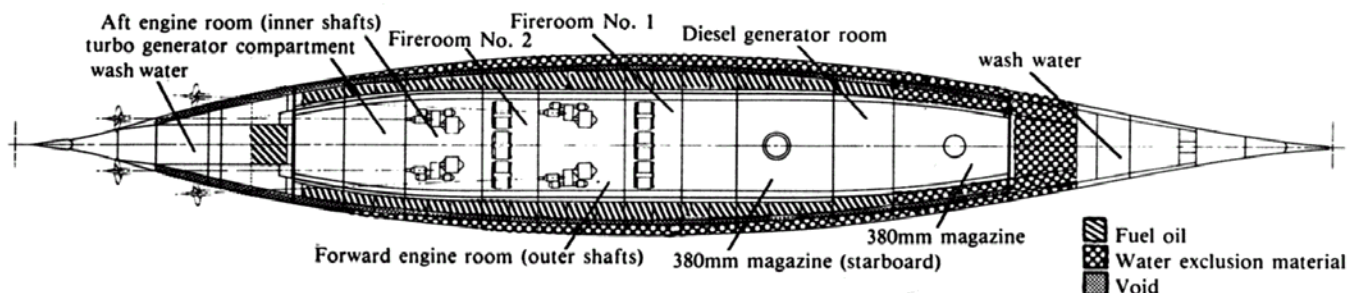
rd Profile with armor disposition (Richelieu) 1940



rd Profile with armored disposition for Gascogne



Machinery Schematic — Hold Plan



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Side protective
system loading Void (foam)—void—liquid—void
Total bulkhead thickness 2.64" (77 mm) at amidships

Underbottom protection
Depth, one layer 3.67' (11.12 m)

Tank Capacities

Richelieu

Fuel oil	6,796 (6905 mt)
Diesel oil	246 (250 mt)
Reserve feed water	236 (240 mt)
Potable water	336 (392 mt)
Lube oil	113 (115 mt)

Jean Bart

Fuel oil	6,476 (6582 mt)
Diesel oil	232 (236 mt)
Reserve feed water	263 (267 mt)
Potable water	463 (471 mt)
Lube oil	113 (115 mt)

Machinery

Boilers Six Sural-Indret (Norguet) small watertube forced-combustion type

	Jean Bart	Richelieu
Pressure	397 psi (27 kg/cm ²)	397 psi (27 kg/cm ²)
Temperature	700°F. (371° C.)	617° F. (350° C.)
Turbines	Parsons type, single reduction gears	
Shaft horsepower	(150,000) normal design (180,000) overload	

	Richelieu	Jean Bart (June 1949)
Maximum speed and trial data	30.31 knots (134,640 mhp; 26.35 " (83,100 mhp)	31.84 knots (162,855 mhp) 32.13 " (176,030 mhp)

Nominal Endurance

Richelieu	Jean Bart
10,000 miles @ 12 knots	8,000 miles @ 15 knots
9,500 miles @ 15 knots	6,900 miles @ 20 knots
7,750 miles @ 20 knots	3,400 miles @ 30 knots
4,800 miles @ 25 knots	
3,300 miles @ 30 knots	

Generators four 1,500-kw turbogenerators, rated at 230/460 volts DC
three 1,000-kw diesel generators, rated at 230/460 volts DC
total electric power, 9,000 kw
two 150-kw emergency generators

Propellers four—15.81 ft (4.87 m)

Rudder one—semibalanced type, maximum hard-over angle = 32°

Miscellaneous

Complement (flagship)

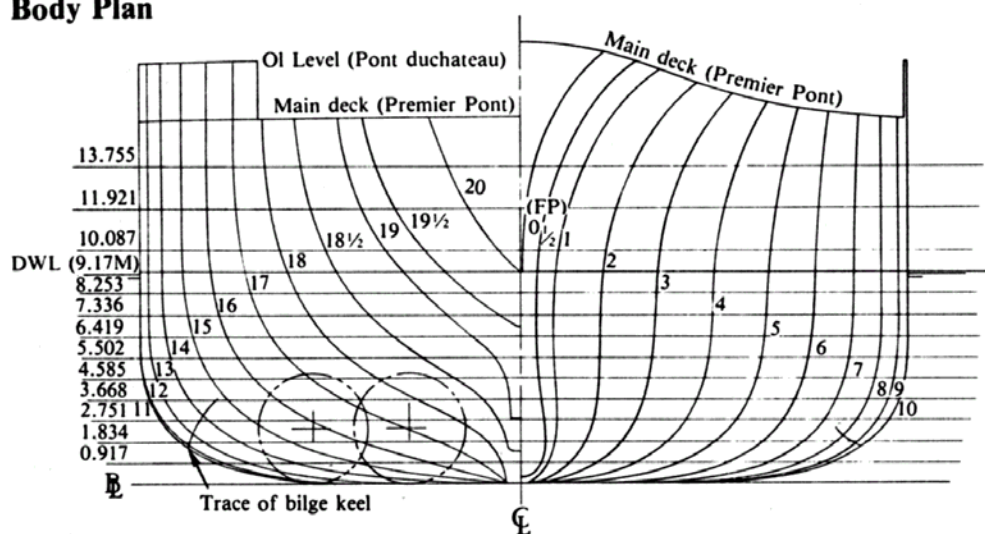
1,550 (86 off./1,464 enl.) Richelieu 1945
2,134 (104 off./2,030 enl.) Jean Bart 1950

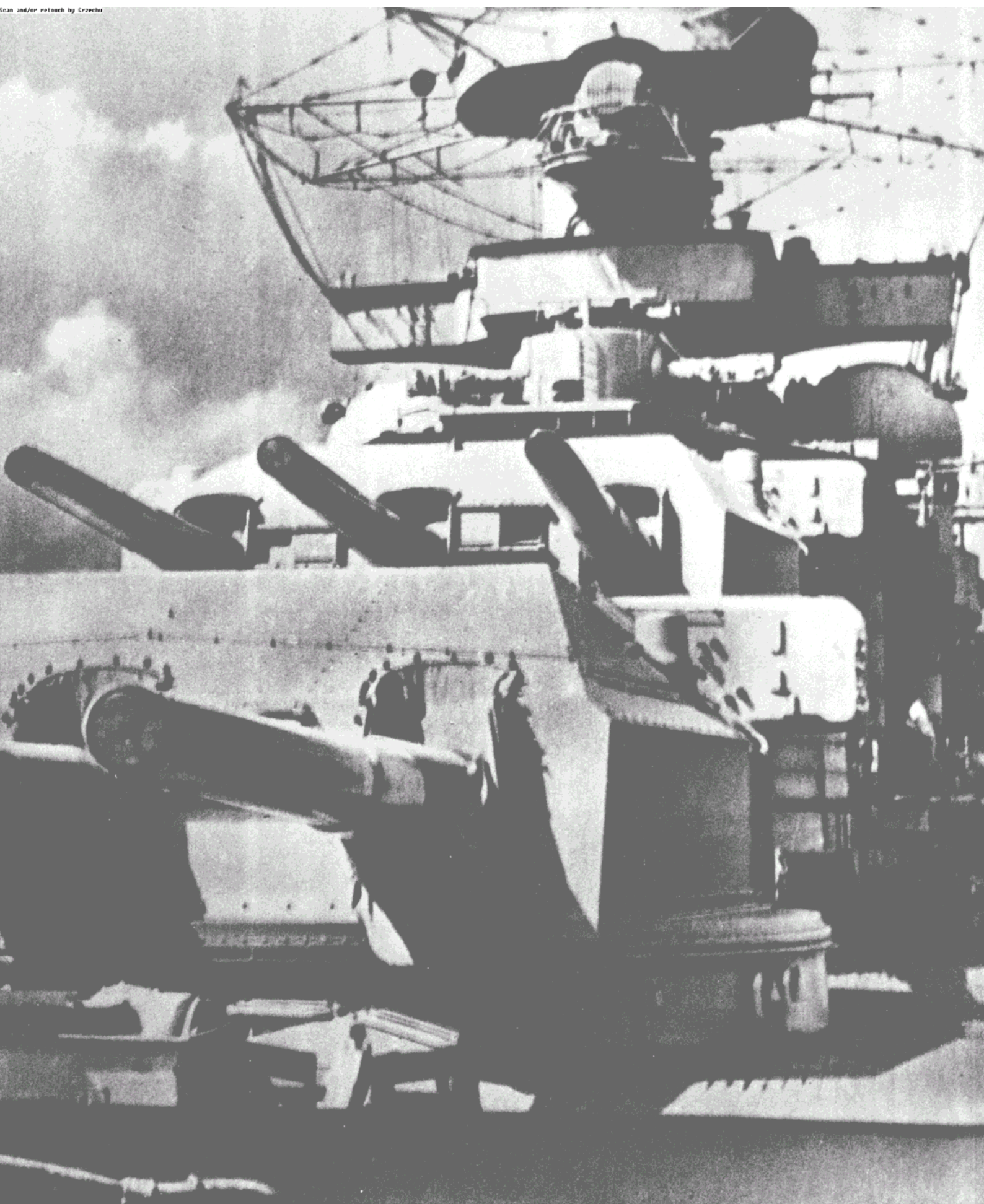
Weights (April 1935)—PN 196

	<i>Tons</i>	<i>Metric tons</i>
Hull, decks, foundations, etc.	9,092	(9,240)
Protection		
vertical	5,025	(5,107)
horizontal	5,495	(5,585)
underwater	1,074	(1,092)
main turrets	3,103	(3,154)
secondary turrets	879	(893)
conning tower	374	(380)
uptakes, paravanes	118	(120)
miscellaneous	466	(474)
Armament		
main	3,685	(3,745)
antiaircraft	1,438	(1,461)
miscellaneous and accessories	311	(316)
directors	246	(250)
aeronautical	108	(110)
detection TSF navigation	39	(40)
Masts and spars	216	(220)
Propulsion	2,322	(2,360)
Fuel	2,066	(2,100)
Additional combustibles	1,051	(1,068)
Reserve feed water	216	(220)
equipment	2,671	(2,715)
Boats	207	(210)
Air in the hull	39	(40)
Total (normal displacement)	40,241	(40,900)

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Body Plan





CHAPTER FOUR

The Netherlands— Design 1047

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During 1938, the Netherlands government surveyed the present state of the Dutch armed forces, incident to the plan to strengthen the Dutch military establishment. In the case of the Royal Netherlands Navy, the primary consideration was the reinforcement of the fleet in the East Indies.

The Dutch concluded that any major Japanese aggression in the Pacific would require a maximum naval effort, primarily against heavy fleet units of the American Pacific Fleet and the Royal Navy's Far Eastern Fleet. So long as the United States and the United Kingdom maintained a major naval presence in the Far East, the Royal Netherlands Navy believed the Japanese would probably be unable to deploy capital ships against the Dutch East Indies. As a result, it was agreed that the East Indies fleet should be reinforced with ships suitable for opposing Japanese fleet detachments centered on heavy cruisers.

Dutch naval authorities decided that the most practical design would be an extremely fast battlecruiser protected against 203-mm shellfire and armed with 283-mm guns. Given the limited means available to the Dutch, this was considered the most realistic scheme for enhancing the protection of the East Indies.

As a consequence, the Netherlands government ordered the development of a new battlecruiser design on 17 February 1939.

The basic design requirements for the battlecruisers are shown in Table 4-1.

TABLE 4-1

Navy Preliminary Design

Displacement	27,000 tons (27,433 mt)
Armament	Nine 11.1" tripled (283 mm) Eight 4.7" paired (120 mm) Fourteen 40-mm Bofors—paired
Shaft horsepower	177,538 (180,000 mhp)
Maximum speed	33 knots (in <i>tropical</i> waters)
Endurance	4,500 nautical miles at 20 knots
Protection	Against 8" (203-mm) shellfire
Complement	1,050 officers and crew

German technical assistance. As the Royal Dutch Navy—Koninklijke Marine—had no recent experience in capital-ship design, the Chief of the Bureau of Construction—Bureau Scheepsbouw—discussed their program with German naval authorities in Berlin on 24-25 April 1939. The Germans were already aware of the Dutch plans, as Dutch shipyards were preparing to purchase additional equipment and facilities from Germany for use in building the new ships.

The Germans were interested in the Dutch designs and willing to supply required construction materials, including armor plate and armament. A German-controlled

This is a view of the 283-mm turrets of the German battlecruiser Gneisenau. These guns and turrets were being contemplated for the Dutch battlecruisers. (Foto Drüppel)

firm in the Hague, the Engineering Bureau for Naval Construction—*Ingenieursbureau voor Scheepsbouw*, hereafter referred to as IvS*—was designated as the mediator. Although very cooperative otherwise, the Germans showed little inclination to give the Dutch any information on their new battlecruisers *Scharnhorst* and *Gneisenau*.

The navy's preliminary design, completed 11 July 1939, was the basis for further study and development. Underwater protection was weak in this design scheme, horizontal armor protection was virtually nonexistent, and the machinery arrangement was inferior due to the concentration of all boilers in adjacent spaces. The principal characteristics of this design are summarized in Table 4-2.

TABLE 4-2

Navy Design of 11 July 1939

Displacement	
(standard)	26,000 tons (26,417 mt)
(trials)	26,574 tons (27,000 mt)
(normal full load)	27,558 tons (28,000 mt)
(full load, approx)	28,300 tons (28,754 mt)
Waterline length	754.6' (230.0 m)
Beam	95.1' (29.0 m)
Draft	24.4' (7.45 m)
Depth	43.963' (13.40 m)
Armament	nine 11.1"/54.5 tripled (283 mm)
	eight 4.7" paired (120 mm)
	fourteen 40-mm Bofors paired
Shaft horsepower	152,880 (155,000 mhp)
Maximum speed	33 knots (in tropical waters)
Endurance	4,500 nautical miles at 20 knots
Main side belt	9.84"; 5.91"-3.94" upper; 3.94" ends (250 mm; 150–100 mm; 100 mm)
Barbettes	9.84" (250 mm)
Conning tower	3.94" sides (100 mm)
	5.12" roof (130 mm)
Upper armor deck	0.59" (15 mm)
Lower armor deck	0.47" (12 mm)
Forward transverse bulkhead	11.81" (300 mm)

The design department of the Bureau of Construction was growing in size, and in August 1939 it moved into space provided by the Netherlands United Naval Construction Bureau—*Nederlandsche Vereenigde Scheepsbouw Bureau*.† Draftsmen and technical experts from that bureau were placed at the disposal of the naval constructors and technical officials of the navy for the detailing of the plans.

The Navy estimated four years would be required to build each ship, at a cost of 71,000,000 guilders (\$28,400,000). The annual operating cost was estimated to be 4,500,000 guilders (\$1,800,000) per ship. The government wanted the first of at least three such ships completed by 1944. The Dutch believed that this schedule presented no foreseeable problems (although the Germans had their doubts), so long as materials manufactured in Germany were received on time.

* IvS was directed by Dr. Ing. Techel, German submarine design expert and Chief Constructor of the Germaniawerft Yard during World War I. Hoping eventually to circumvent the restrictions of the Versailles Treaty, Techel founded IvS in the Netherlands, staffed it mostly with Dutchmen. Submarines were designed for Finland, Turkey, and Spain, the cruiser *De Ruyter* for the Netherlands, and small armored ships for Finland.

† A combined design bureau for the four major Dutch commercial shipyards.

The armed forces of the Netherlands were mobilized at the end of August 1939. Relations with Germany became increasingly more difficult as tensions increased. Soon, the Germans indicated there might be problems in delivering armor, but the Dutch were hopeful that these problems could be overcome.

On 31 August 1939 a sketch plan prepared by the Ship Construction Office of the German Navy was forwarded from Berlin to the German naval attaché at the Hague. This rough battlecruiser plan, the first evidence of the German design assistance that was to become increasingly important as time passed, had the characteristics presented in Table 4-3.

TABLE 4-3

German Design of 31 August 1939

Waterline length	744.8' (227.0 m)
Beam	98.4' (30.0 m)
Draft	26.247' (8.0 m)
Depth	45.9' (14.0 m)
Armament	nine 11.1"/54.5 tripled (283 mm) eight 4.7" paired (120 mm) sixteen 40-mm Bofors paired
Shaft horsepower	169,647 (172,100 mhp)
Maximum speed	33 knots
Endurance	5,500 nautical miles at 20 knots
Main side belt	8.86" (225 mm); 1.18" (30 mm) upper; 1.18" (30 mm) fwd.; 2.36" (60 mm) aft; 4.92" (125 mm) slopes
Barbettes	8.86"-6.89" (225 mm-175 mm)
Upper deck	1.18"-0.79" (30 mm-20 mm)
Armor deck	3.94" (100 mm)

In October 1939, Dr. Techel advised the Dutch designers that the Germans felt that the breadth of the side protection system should be as much greater than 4.5 meters as was possible.

In mid November, during discussions with IvS and German authorities, IvS presented a plan, presumably based on the one sent from Berlin in August. After several conferences, a compromise between the navy and the IvS plans was reached, although several difficulties remained unsolved. The German plan provided insufficient deck area for the machinery and boiler rooms, and the magazines were too small. The machinery arrangement problems could be resolved by the use of smaller high-pressure boilers, which the Germans had favored from the beginning.

The first navy revisions of the preliminary design resulted in a larger ship, as might be expected, as more and more requirements were imposed. Details of this design, for which the completion date is unknown, are listed in Table 4-4.

As a result of serious design problems, Dutch engineers and naval officers visited several Italian yards to discuss the design with Italian experts. They were permitted to visit the *Vittorio Veneto*, then nearing completion, but not the incomplete *Roma*, possibly because the Italians wanted to keep secret the Pugliese concept of side protection.

The Italians, who were well informed about the *Scharnhorst* and *Gneisenau*, gave the Dutch more information about the German battlecruisers than they had been able to obtain directly from the Germans.

After considering the new information and suggestions obtained from the Italians, the Dutch decided it was necessary to modify the design to bring it up to modern standards; they informed the Germans that they were willing to continue discussions, but only if the talks could be held on a more candid basis than in the past.

TABLE 4-4
Battlecruiser Design Studies

<i>Design Scheme</i>	<i>Navy Design Development 1939</i>	<i>I.v.S. (Techel) Plan 18 March 1940</i>
Standard displacement	27,500 tons (27,940 mt)	29,815 tons (30,292 mt)
Trials displacement	...	...
Full-load displacement	30,402 tons (30,890 mt)	32,676 tons (33,200 mt)
Waterline length	771' (235 m)	782.2' (238.4 m)
Beam	98.4' (30 m)	95.1' (29 m)
Draft	26.7' (8.15 m)	27.6' (8.4 m)
Hull depth	45.9' (14 m)	47.6' (14.5 m)
Main battery 11.1"/54.5 (283 mm)	9	9
Secondary battery 4.7" (120 mm)	12	12
Machine guns 40 mm	16	16
13 mm	16	16
Armor thicknesses		
Main side belt	8.86" (225 mm)	8.86" (225 mm)
Barbettes	...	...
C. T. front	...	...
C. T. roof	...	...
Upper armor deck	...	...
Lower armor deck	...	...
Projectile against which protected	8" (203 mm)	8" (203 mm)
Speed, knots	34	34
Shaft horsepower	177,538 (180,000 mhp)	same
Endurance @ 20 knots	4,500	same
Catapults	1	1
Aircraft	3	3

Parenthetical values are metric equivalents of English units (e.g., 27,500 tons equals 27,940 metric tons).

The IvS battlecruiser design was completed in March 1940. This design (also in Table 4-4) served as the basis for further consultations with the Germans in April 1940. The type of boilers to be installed remained undecided, as the Dutch hesitated to accept the German high pressure and temperature boilers. The Dutch felt, correctly, that the German boilers were not service-tested and were potentially unreliable.

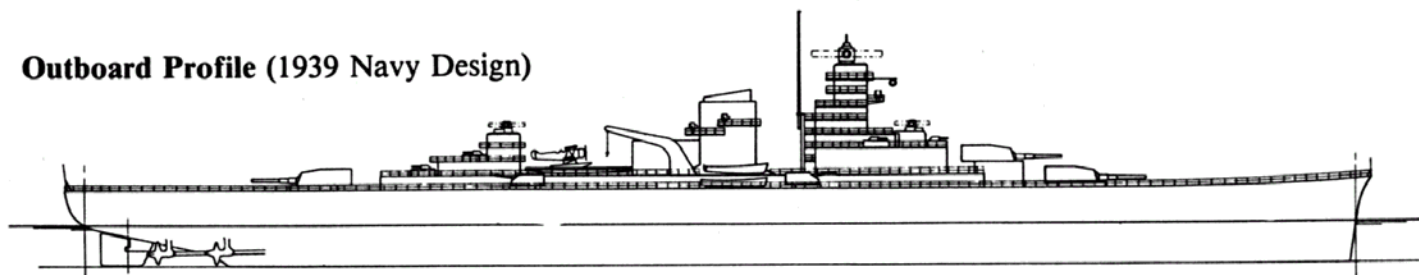
The last design completed prior to the German invasion was a navy scheme, dated 19 April 1940, which had the characteristics listed in Table 4-5.

Design 1047 was never completed. An approximation of the "definitive" design (Table 4-6) was prepared in 1960 by a member of the design team that had

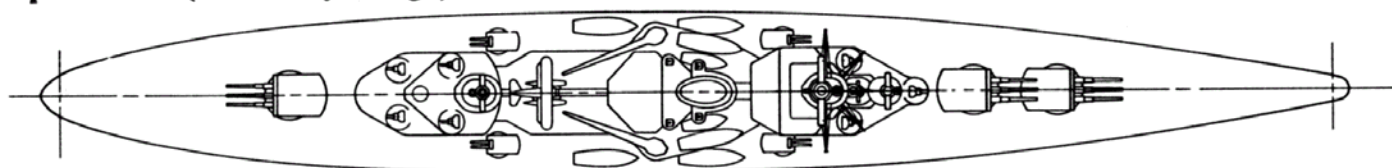
TABLE 4-5
Navy Design of 19 April 1940

Trial displacement	29,313 tons (29,783 mt)
Full-load displacement	30,900 tons (31,395 mt)
Waterline length	774.3' (247.522 m)
Waterline beam	96.4' (29.4 m)
Metacentric height	9.2' (7.8 m)
Armament	nine 11.1"/54.5 tripled (283 mm) twelve 4.7" paired (120 mm) fourteen 40 mm paired sixteen 13 mm paired
Shaft horsepower	177,538 (180,000 mhp)
Speed	33 knots

Outboard Profile (1939 Navy Design)

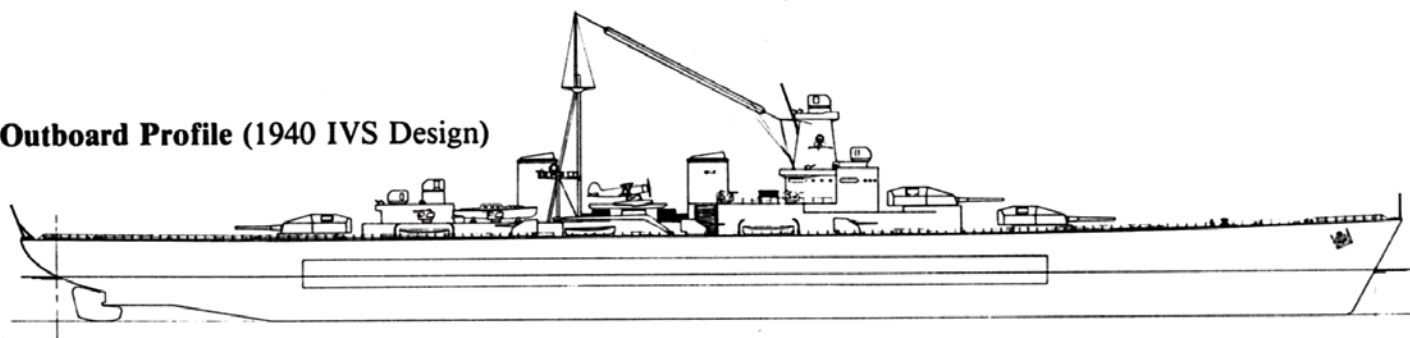


Topside View (1939 Navy Design)

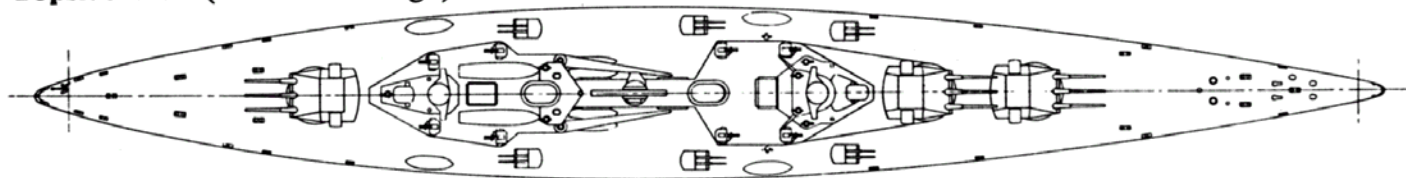


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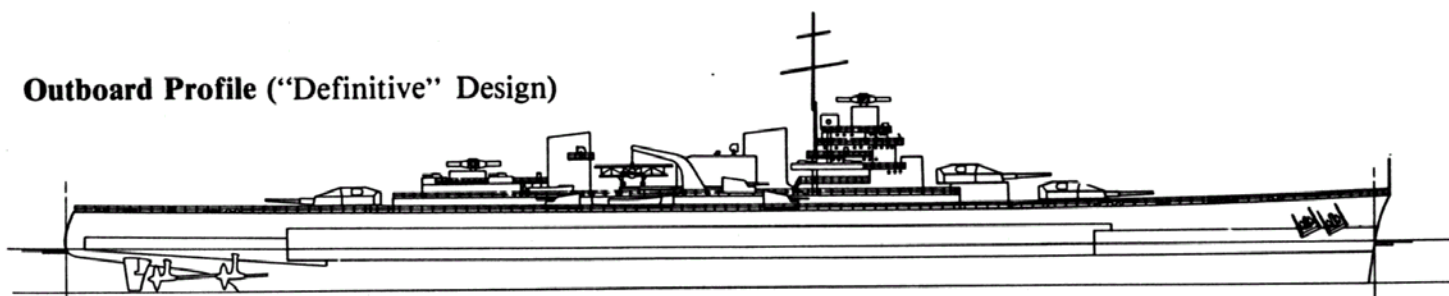
Outboard Profile (1940 IVS Design)



Topside View (1940 IVS Design)



Outboard Profile ("Definitive" Design)



Topside View ("Definitive" Design)

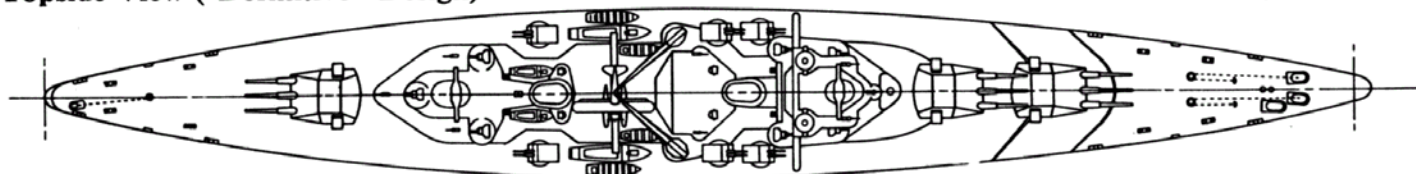


TABLE 4-6
"Definitive" Design 1047

Standard displacement	28,064 tons (28,516 mt)
Trials displacement	27,872 tons (28,319 mt)
Full-load displacement	30,968 tons (31,466 mt)
Waterline length	777.8' (237.1 m)
Beam	98.4' (30 m)
Draft	25.6' (7.8 m)
Hull depth	45.9' (14 m)
Armament	nine 11.1"/54.5 (283 mm) twelve 4.7" (120 mm) fourteen 40-mm Bofors—paired sixteen 13 mm—paired
Armor protection	
Main side belt	9.84" (250 mm)
Barbettes	9.84" (250 mm)
Conning tower	
roof	5.12" (130 mm)
front	11.81" (300 mm)
Upper armor deck	3.94" (100 mm)
Lower armor deck	1.18" (30 mm)
Projectile against which protected	8" (203 mm)
Speed, knots	34 knots
Shaft horsepower	177,538 (180,000 mhp)
Endurance at 20 knots	4,500 miles
Catapults	1
Aircraft	3

worked on the project in 1940. This should be considered as an informed estimate of the Dutch design thinking as of the German invasion in May 1940.

Construction preparations. In planning the construction of these battlecruisers, the Dutch navy believed that a minimum of three such ships were required. The only shipyards in the Netherlands capable of constructing such large ships were: Rotterdam Drydock Co., Rotterdam; Netherlands Naval Construction Co., Ltd., Amsterdam; Royal Society De Schelde, Flushing; and Dock and Construction Co., Wilton-Fijenord, Ltd., Schiedam. The Netherlands Naval Construction Co., Ltd., began work on a new building way 250 meters long as soon as it was learned that the navy was planning the new battlecruisers. For a long time, it was known as the *slagkruiserhelling*—battlecruiser way. The Dutch also planned a 40,000-ton capacity drydock, and funds were allocated for the improvement of the naval base at Soerabaja in the Netherlands East Indies.

Armament. Guns projected for the battlecruisers had the characteristics given in Table 4-7.

Main battery. All guns were to be manufactured in Germany by Krupp. The fire-control equipment was to be manufactured by *Hollandsche Signaal Apparaten Fabriek Hazemeyer*, one of the leading manufacturers of such equipment in Europe.

The Dutch designers desired a main-battery gun capable of defeating any existing heavy cruiser. The German 283-mm gun, of the same basic type as those mounted in the *Scharnhorst* and *Gneisenau*, would have met this requirement. Severe damage inflicted on the British heavy cruiser *Exeter* by similar 283-mm guns of the *Admiral*

TABLE 4-7

Gun Data

Gun	11.1"/54.5 (283 mm)	4.7"/50*(120 mm)
Shell weight (lbs)	694 (315 kg)	52.9 (24 kg)
Muzzle velocity (fps)	2,953 (900 mps)	2,950 (899 mps)
Maximum range (yds)	46,590 (42,600 m)	21,870 (20,000 m)
Maximum elevation	45°	70°

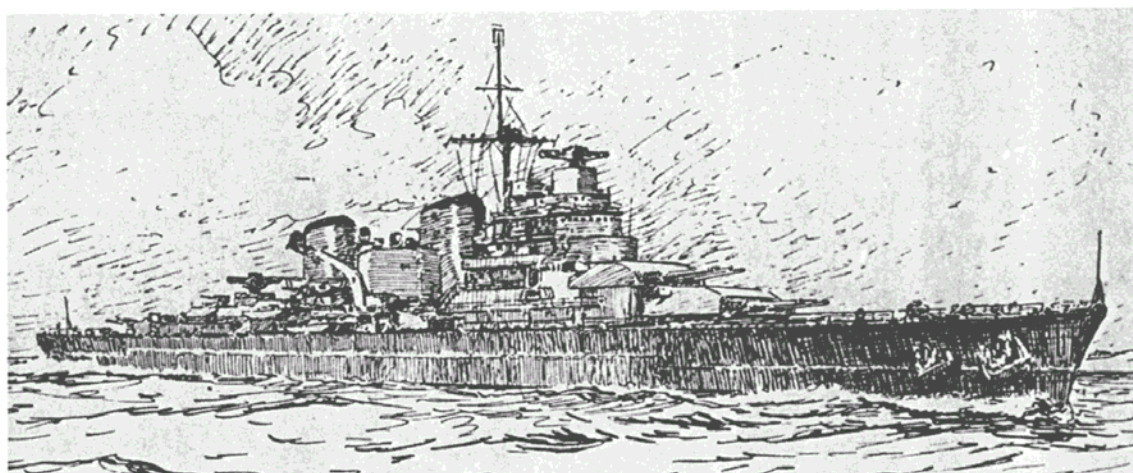
* Data is for a Bofors gun introduced into service in 1934. The data is representative only.

Graf Spee in the Battle of the River Plate during December 1939 proved that the 283-mm gun could out-range the 203-mm guns of heavy cruisers and devastate the cruisers at such ranges that the battlecruiser was nearly invulnerable to their return fire.

Secondary battery. The Dutch decided early on the secondary armament. The preliminary design mounted only eight 120-mm guns in twin mounts. All later schemes included twelve 120-mm guns arranged in twin mounts, three on each beam. The secondary armament was comparable to that in contemporary ships of similar displacement, although combat would prove the desirability of greatly increased anti-aircraft batteries.

Antiaircraft. The 40-mm Bofors machine gun was consistently projected, with a total of seven twin mounts in the later designs supplemented by sixteen 13.2-mm machine guns in twin mounts. This machine-gun battery would have proved inadequate due to the limited numbers involved. If the ships had been built, their machine-gun batteries would eventually have become far more numerous.

Protection. Although the details were never completed, it is clear that the Dutch wanted armor protection against 203-mm shellfire at normal battle ranges. The result was armor which would have made the citadel virtually immune to such fire at ranges over 9,000 meters.



An artist's conception of Design No. 1047. These would have been handsome warships, reflecting the pronounced German influence on their design.

The following discussion is based on the "definitive" design, which may be considered a good representation of 1940 Dutch doctrine on the protection of these battlecruisers.

Side and deck armor. As might be expected from a design subject to German influence, the armor system was essentially of the conventional turtle-back design, although the main side belt had a modest outboard inclination of about ten degrees. The belt armor, 250-mm thick, was the equivalent of vertical plates about 280-mm thick, while the lower deck slopes increased the total resistance to that of approximately 330-mm plates. The deck-armor system provided good protection at ranges approaching the maximum for 203-mm guns. The upper armor deck was 100-mm thick, while the lower deck was 30-mm thick.

Barbette armor. Barbette armor of 250 mm, with 300-mm armor for conning-tower sides and 133-mm conning-tower roof plates, all combined to give excellent protection against shellfire from heavy cruisers.

All in all, the armored citadel provided remarkably complete protection against the weapon it was designed to resist, the 203-mm gun. Capital-ship guns, on the other hand, could deal heavy damage to the battlecruisers before the latter's 283-mm guns would have been able to do any damage in return. A modern 406-mm gun could penetrate the armor system at all battle ranges, with long-range plunging fire posing an especially severe threat.

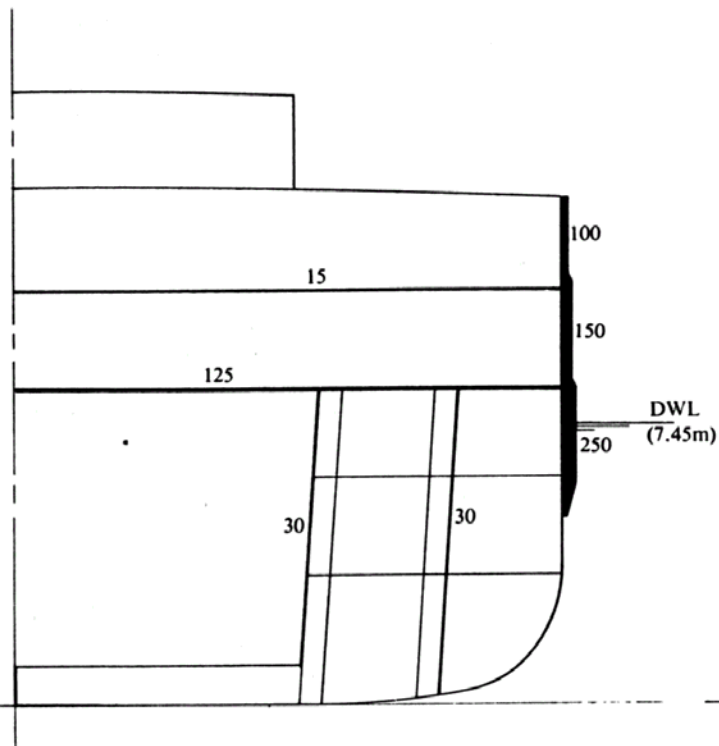
While the basic armor scheme was reasonably well established once it was decided that 203-mm shellfire was to be the standard for armor protection, there was no such consistency and assurance in the design of the side protection system.

Side protection design problems. The side protection system of the preliminary design scheme of 11 July 1939 was quite simple, albeit relatively deep. At half-draft, the transverse extent of the system was about 6.7 meters. Outboard, a void compartment some three meters deep permitted the initial unrestrained expansion of the gas bubble, while the single compartment inboard was to be liquid-loaded. The basic arrangement of the system was similar to that employed in German capital ships. Both the backing bulkhead and the holding bulkhead were made from 30-mm plates. The fundamental weakness of this system was the excessive width of the outboard void compartment, which made excessive lists very probable in the event of underwater damage.

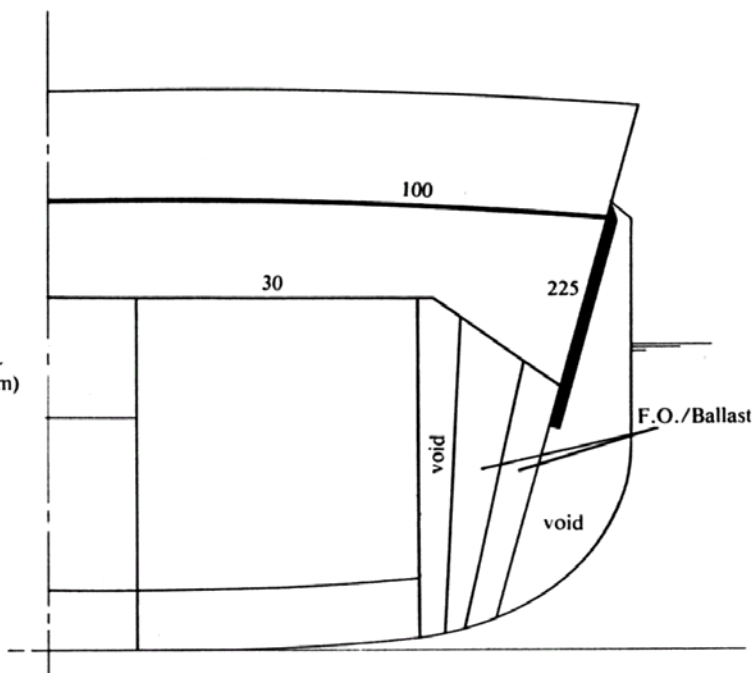
Italian naval architects considered several of the basic features of the underwater protection of this preliminary design scheme to be obsolete. In particular, they recommended that the distance between the holding bulkhead and the shell plating be increased, and they suggested that the double-bottom structure should be about three meters deep to better withstand mine attack. Although the *Vittorio Veneto*-class ships lacked such a feature, they recommended that the top plate of the double bottom should be armored, if at all possible. The Italians likewise recommended that the liquid-loading schemes for the battlecruiser protection system should be investigated, and they expressed a willingness to conduct scale-model tests of such systems if the Dutch would agree to pay all expenses. No further assistance was sought from the Italians, however, and no scale-model tests were conducted.

The navy midship-section scheme of 4 January 1940 was similar to American side protection system designs of the same era. The system, totaling some 6.4 meters on either side amidships, featured a large void outboard compartment with two liquid-loaded compartments sandwiched between it and another void compartment adjacent to the 40-mm holding bulkhead. This was a superior design, for it greatly reduced the

Midship Section (1939 Navy Design)

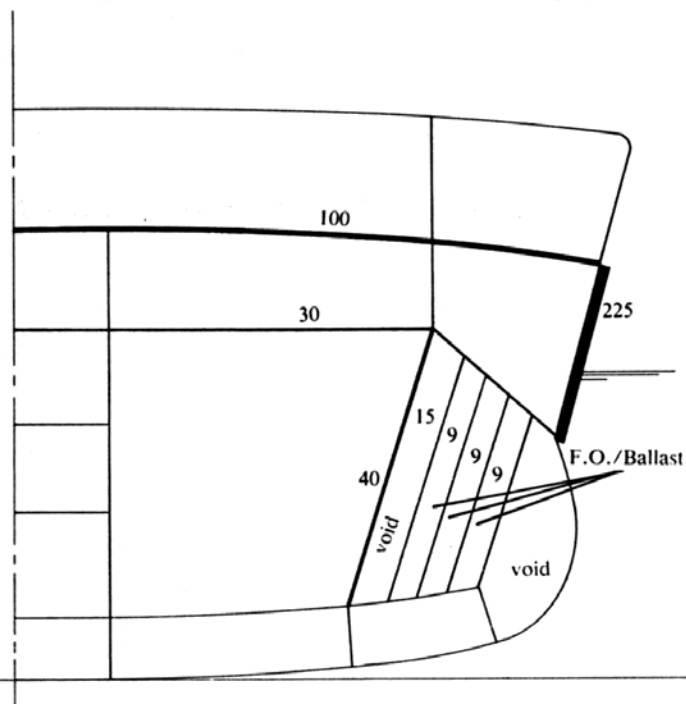


Midship Section (4 Jan 1940 Navy Design)

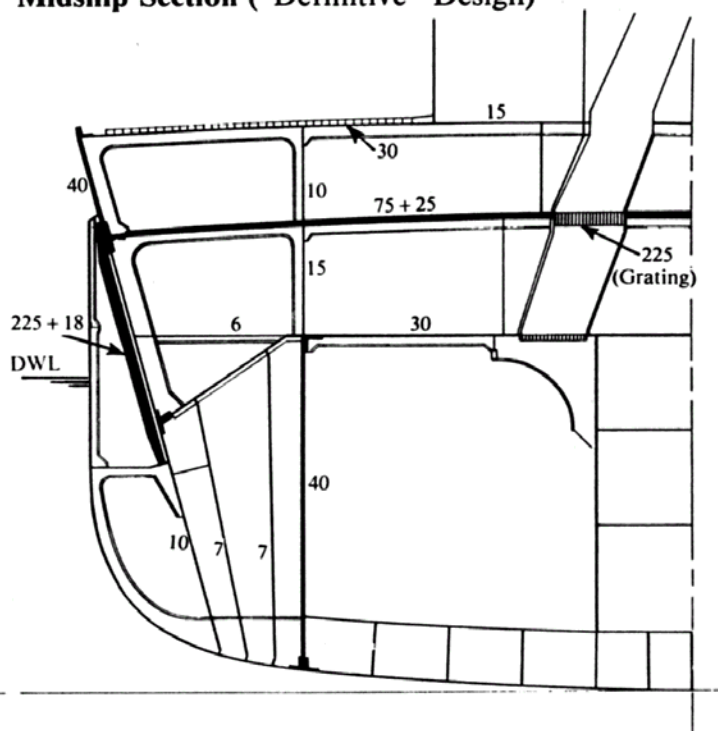


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Midship Section (11 Mar 1940 IVS Design)



Midship Section ('Definitive' Design)



size of the outboard void compartment while permitting greater absorption of explosive energy by the two inboard bulkheads of the liquid-loaded compartments. The midship section was wall-sided, with the inclined armor comprising part of the inboard bulkhead of the outboard void compartment.

The 11 March 1940 IvS midship-section design was conceptually similar to the January navy plan, although it differed markedly in detail from the earlier scheme. With an average extent of about 6.1 meters, three liquid-loaded compartments were arrayed in a manner similar to that of the earlier navy plan. In this design, however, all bulkheads were inclined from the vertical, the inclined belt armor was part of the shell of the ship, and a blister structure was apparent. One major deficiency, in what would otherwise have been the best of the protective scheme designs, was the continuation of the double-bottom structure over part of the side protection system. This confined the added protection of the liquid layers to about the top two-thirds of the submerged depth of the hull amidships.

The last navy design study, dated 10 April 1940, represented in many respects a reversion to German design practice, with a modest bulge structure and a single void compartment outboard of a large liquid-loaded compartment. This system, about 6.4 meters deep, probably was proposed in an effort to reduce the structural weight associated with the underwater protection of the ships. Certainly, in all other respects, the system was inferior to the two schemes previously considered.

The design of the side protection system had not yet been resolved by the time of the German invasion. The general trend in the design process seems to have been a sound one, with the exception of the last scheme. These ships were of a marginal size to permit the installation of a truly effective side protection system (the U.S. *Alaska*-class ships, of a similar size, had none), and this was apparent in the difficulties encountered in developing the system.

Propulsion Plant. High speed, of paramount importance for service in the sprawling Dutch East Indies, was obtained at the price of limited endurance and modest offensive and defensive capabilities.

Early in the development of the design, a set of calculations for the optimum length for a given maximum speed and endurance was completed, as presented in Table 4-8.

Model experiments in the Wageningen towing tanks were completed in February 1940. These indicated that the propulsive efficiency of the battlecruisers was excellent, approaching that of destroyers. Furthermore, they indicated that, in the clean

TABLE 4-8
Speed-Length Calculations

Displacement	28,356 tons (28,811 mt)		
Maximum beam	98.425' (30.0 m)		
Draft	25.59' (7.8 m)		
Waterline length	754.59' (230 m)	77.99' (235 m)	787.40' (240 m)
Midship coefficient	...	0.910	0.893
Wetted surface	...	79,007 ft ² (7,340 m ²)	79,836 ft ² (7,417 m ²)
SHP required for:			
34 knots	184,601 (187,161 mhp)	173,414 (175,820 mhp)	163,346 (165,612 mhp)
33 knots	150,907 (153,000 mhp)	143,738 (145,730 mhp)	137,810 (139,721 mhp)
20 knots	24,103 (24,438 mhp)	23,979 (24,312 mhp)	23,853 (24,184 mhp)
Endurance	4,500 nautical miles at 20 knots		

TABLE 4-9

Speed-Power Calculations

Displacement	28,568 tons (29,026 mt)		
Waterline length	777.89' (237.1 m)		
Beam	98.425' (30.0 m)		
Draft	25.59' (7.8 m)		
Wetted surface*	71,967 ft ² (6.868 m ²)		
Speed	EHP**	SHP**	EHP/SHP
36 knots	142,030 (144,000 mhp)	228,826 (232,000 mhp)	0.621
35 knots	117,865 (119,500 mhp)	190,360 (193,000 mhp)	0.619
34 knots	97,646 (99,000 mhp)	156,825 (159,000 mhp)	0.623
33 knots	80,385 (80,385 mhp)	129,702 (131,500 mhp)	0.620
20 knots	13,611 (13,800 mhp)	22,488 (22,800 mhp)	0.605
Endurance	4,500 nautical miles at 20 knots. (About 2,579 tons [2,621 mt] of fuel would be required. This would be less for a longer ship, greater for a smaller.)		

* Without appendages, but including rudders.

** EHP = Effective Horsepower—The power transmitted to the water to propel the ship. The EHP is the equal of the total resistance of the ship.

SHP = Shaft Horsepower—The power delivered to the reduction gearing. The difference between the EHP and SHP reflects losses in reduction gearing, shafting, bearings, and propeller inefficiencies.

condition, the battlecruisers should be able to approach 34.5 knots maximum speed in temperate waters (Table 4-9).

Although the speed requirement was 33 knots, the provision of power for 34 knots was not an instance of overdesign. On the contrary, it was recognition of the fact that the higher water temperatures in the tropics reduce the efficiency of steam-turbine plants by decreasing the vacuum that the main condensers are able to develop. The resultant loss of power is appreciable, hence a 34-knot speed capability in northern waters would be equivalent to approximately 33 knots in the tropics. (As can be seen in Table 4-9, a one-knot maximum speed loss represents a substantial power loss—almost 20 percent).

Despite the strong German influence, all design schemes featured a four-shaft arrangement in preference to the typical German three-shaft arrangement. The Dutch preferred four shafts because of the subdivision that they desired in the design of the propulsion plant.

The preliminary design had a very undesirable highly concentrated arrangement of the propulsion plant, with four boiler rooms forward and two engine rooms aft. Such an arrangement, frequently dictated by space and weight considerations, markedly increased the possibility that the machinery could have been disabled by a single torpedo hit or mine detonation. Without a sufficiently deep torpedo-defense system, such an arrangement was extremely bold and risky. All the uptakes were trunked into one large funnel, an arrangement very vulnerable to fragmentation damage to extensive uptakes.

Later design schemes avoided this danger by interposing one of the engine rooms between the boiler rooms forward and the boiler rooms farther aft. Even so, on 29 March 1940, subsequent to a visit to Italy by the Chief of the Bureau of Construction, the machinery arrangement of the IvS design was discussed. The primary subject of discussion was the dividing of the boiler complex, apparently suggested by the Italians after studying the Techel design.

The "definitive" scheme would have provided a more conventional machinery arrangement, for the two widely spaced funnels clearly indicate that the boiler rooms were well separated. This was necessary to obtain effective battle-damage resistance

for the propulsion plant. This type of arrangement materially reduced the chances for a total loss of power as a result of one shell, mine, or torpedo hit.

Although the required 180,000 metric horsepower was to be provided by four sets of geared turbines to be manufactured in Germany, the steam conditions and the type of boilers had not been established by May 1940. The Germans favored the high pressure and temperature type installation used in their large warships, with resultant weight and space economies, but the Dutch were reluctant to adopt such plants because of their unproven reliability. These misgivings were well founded, for the *Scharnhorst* had boiler trouble with her superheater tubes early in her career. This was attributed to the improper material having been stipulated in her specifications.

Space problems encountered late in the design period probably would have forced the Dutch to accept the German-advocated high-pressure plant, if they were to obtain the desired power. This decision, however, had not been made by May 1940.

The German boiler and turbine manufacturer involved in the negotiations with the Dutch navy was *Deutsche Schiff- und Maschinenbau A. G., Werk A. G. Weser* of Bremen. Had the Dutch decided to accept the lower pressure and temperature installation, the boilers would have been produced by the *Werkspoor* firm in Amsterdam.

Electric plant. The primary electrical system was designed to operate with direct current, using alternating current for special purposes. A memorandum of 28 February 1940 refers to an installation with two 300-kva turbogenerators with two additional 150-kva alternating-direct current motor generators. The Dutch navy wanted two 625-kw DC turbogenerators and one AC turbogenerator set. Many auxiliaries would have had nonelectric power—hydraulic power for turrets, steam winches, steam steering, etc.

Summary. Although these battlecruisers were designed for operations against heavy cruisers, some consideration must be given to their potential suitability for operations against capital ships. Modern naval history is replete with examples of battlecruisers engaging battleships, usually with disastrous consequences for the battlecruisers. In such actions, the Dutch battlecruisers would have been in a desperate position in a gunnery duel with a battleship. While their protection was good for battlecruisers, it was at best marginal for any engagement with a capital ship. Similarly, their 283-mm guns were of marginal effectiveness against battleships designed to withstand shellfire from 406-mm guns. Unquestionably, these battlecruisers were incapable of operating in the line of battle in a traditional fleet-type engagement against capital ships.

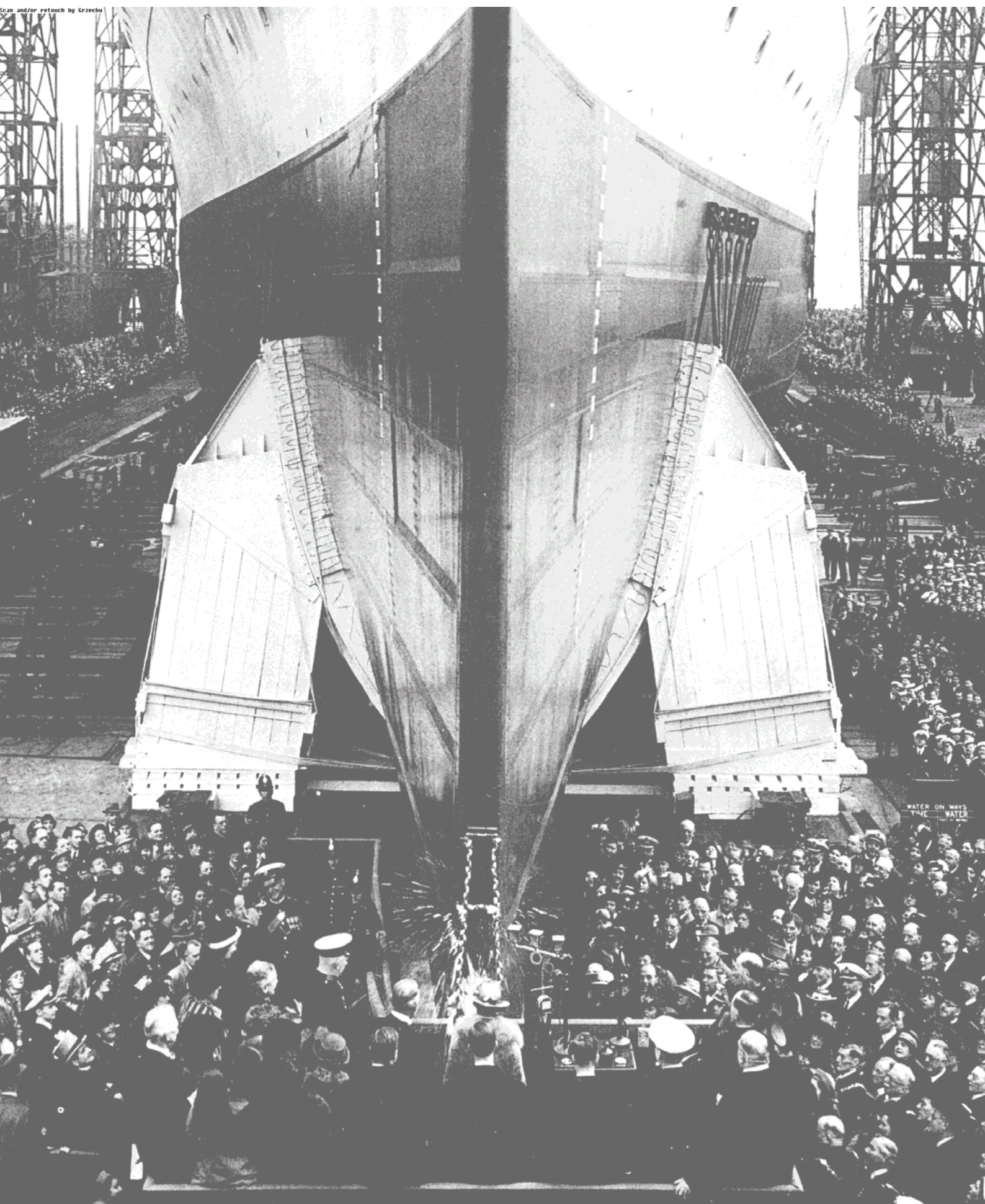
Some of the battleships in service at the time of the projected completion date for the Dutch battlecruisers were capable of similar maximum speeds. The era of the fast battleship doomed the battlecruiser concept, for it no longer was possible to expect that a relatively weakly protected battlecruiser could outdistance a superior opponent. In fact, even the fast battleship could deal very effectively with the heavy cruisers these ships were to counter.

To evaluate fairly the success of a warship design, it is necessary to consider the situations likely to confront the completed ship. Similarly, it is also important to evaluate the designer's success in satisfying the design constraints imposed on him. In this case, the Dutch naval constructors apparently would have brilliantly satisfied the design requirements for ships capable of overwhelming enemy cruisers. In 1941-42, the Japanese were able to deploy their battleships and battlecruisers in the southwestern Pacific. The presence of Japanese capital ships was not anticipated by the Dutch

planners, and their projected new battlecruisers would have been at a severe disadvantage if called on to engage even the modernized World War I-era capital ships of the Imperial Japanese Navy. The Royal Netherlands Navy simply did not have the resources to cope with the requirements of defending against a substantial portion of the strength of the Imperial Japanese Navy in the Dutch East Indies.

This battlecruiser design was good, if not outstanding, with an efficient hull form and adequate armor protection and armament. The ship would have had sufficient capabilities to make success likely in any engagement with heavy cruisers. The designers should have sought a higher maximum speed for the battlecruisers, even at the price of sacrificing a modest side protection system, in order to increase their speed superiority over the cruisers they were designed to engage.

Although construction was never begun, it is clear that the Dutch navy was well on its way towards completing the designs of ships which would have been admirably well suited for their role as "cruiser killers" in Dutch East Indies waters.



WATER ON WAYS
TIME WATER

CHAPTER FIVE

The King George V class

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Great Britain, having built the first dreadnought type in 1906 (and the first aircraft carrier in World War I), perhaps decided the ultimate fate of the battleship during the period between the two world wars. After the completion of the *Nelson* and *Rodney*, thought turned to replacements for the battle fleet—of which the four *Iron Duke*-class battleships were the oldest—as the Washington Treaty clause on new battleship construction expired on 31 December 1931. Since capital ships had grown enormously in size and cost, the Admiralty was in favor of smaller ships, but this would not be possible without some international agreement that would reduce the 35,000-ton limit agreed upon in the 1922 Treaty.

Hopes for such an agreement had been raised when, at the invitation of President Coolidge of the United States, the major naval powers convened a disarmament conference in Geneva in June 1927. In preparation for the conference, the Director of Naval Construction thought it wise to prepare several battleship designs of 28,000-ton displacement and an armament of nine 14-inch guns. Such designs would determine the practicality of an armament and displacement smaller than the treaty limits. The conference convened, but without France and Italy. This was an ominous sign, since the conference was marked with bitter discussions and accusations. In fact, the conference saw a display of sheer animosity between the United States and United Kingdom that was never exhibited in public again. The United States wanted parity with the United Kingdom in terms of battleships and cruisers, while the British were convinced that their world-wide empire justified a preponderance in cruiser strength vis-a-vis the U.S. Navy. The United States would not commit itself to the smaller battleship until after 1931. The parties were unable to resolve their differences or alter their stance, and aggregate cruiser strength remained unlimited by treaty. No agreement was reached, and the future limitations of battleships seemed to be as obscure as they had been before the conference convened.

It was decided by the Admiralty to proceed with the conceptual design of several battleships armed with 12-, 14-, and 16-inch guns and with displacements of 25,000, 28,000, and 35,000 tons. More in-depth studies continued into 1928, when a number of designs were produced. A decision on gun size was necessary so that the preliminary and contract designs could be completed by 1931. The four *Iron Duke*-class battleships were scheduled to be scrapped in 1934, and the Admiralty had hoped for a replacement. The early battleship studies featured twin-mounted main-battery guns, separate anti-aircraft and surface armament, 23-knot maximum speed, and modest armor protection. The greatest emphasis was placed on the design with 12-inch guns,

Launchings of capital ships always drew large crowds and many dignitaries. The Prince of Wales is christened by the Queen at the Cammell Laird Shipyard, Birkenhead, on 3 May 1939. Princess Elizabeth is the little girl hiding in the corner. This battleship was destined to become the only modern Allied battleship to be lost during World War II. (Stewart Bale, Ltd.)

since in future disarmament negotiations the Admiralty intended to press for ships with limitations on displacement of 25,000 to 28,000 tons. In reflection on these paper studies, notable advances were to be accomplished. Larger angles of elevation were to be used for the main-battery turrets, which meant longer ranges, greater angle of fall of the projectile, and as a consequence, thicker deck-armor protection. It is interesting to note that most of these designs featured a speed of 23 knots—the speed of the battle fleet. Several designs were studied for smaller battleships with 10-inch guns and displacements ranging from 20,000-23,300 tons. These studies were probably made because France and Italy were discussing small battleships of this size, and the Admiralty was interested in what type of ship would result.

In June 1929 the Labour Party won the parliamentary elections and Ramsay MacDonald became Prime Minister again. Unlike his predecessor, Stanley Baldwin, he was in full charge of events. He knew what he wanted and was determined to obtain it; he was particularly interested in continuous negotiations for peace. Shortly thereafter, his government communicated a wish to the United States for another naval conference. This undoubtedly was prompted by the American Cruiser Bill, which received senate approval in early February 1929. Also, the British realized that they could not possibly compete with the American shipbuilding potential, even though there was sizable opposition to the program within the United States. On 21 January 1930 the first London Naval Conference convened, and all the major signatories of the 1922 agreement were present. Britain quickly put forward its proposal for 12-inch battleships of 25,000 tons or 11-inch battleships of 22,000 tons. It was evident, however, that France, Italy, Japan, and the United States were not in favor of such ships. Intense pressure was placed by British negotiators on France and Italy to accept such ships, since they were planning for new construction. Nevertheless, after much debate these two countries withdrew, and the final agreement—signed only by the United States, Great Britain, and Japan—postponed the question of battleship size and construction until 31 December 1936. Another conference would have to be held to settle the question. The conference did, however, foster greater understanding between the United States and Great Britain. This would have its effects in warship design of the two countries later in that decade.

While the conference was in session, Prime Minister MacDonald expressed the hope that an agreement could be reached that would in time force the costly and massive battleship, which he deemed of doubtful utility, from the face of the earth. The nonsuccess of the conference did not deter him; he continued his policy of political idealism in the arms field. Private diplomatic negotiations continued with France and Italy to try and convince them to accept battleships of smaller size. These efforts proved fruitless. In the meantime, Great Britain passed through a severe economic recession. With budget cuts in the military expenditures, it was possible only for the Admiralty to proceed with a limited reconstruction of its older battleships.

Discussions of the characteristics for the new battleships to be constructed in 1937 began in 1933. The controller submitted a memorandum to the assistant chief of the naval staff requesting an early delineation of these ships' characteristics. Although studies had been done in the late 1920s, it was felt that changing technology warranted further investigations. By April 1933 the naval staff was busy formulating requirements for the new ships. By June 1933 the Staff Requirements (Table 5-1) for the *King George V*¹⁴⁵ battleships were prepared and submitted to the controller for his review and approval.

These requirements were drawn up under different circumstances from those of past British battleship and battlecruiser designs. Previous designs had progressed in a rather linear manner regarding gun caliber and displacement, but in the post-treaty era these two items were based upon naval limitations achieved through diplomatic

TABLE 5-1

King George V Class—Preliminary Design Requirements

Armament	
main	eight guns in four turrets or nine in three turrets
secondary	six dual-purpose 6" guns with an elevation of only 30°.
antiaircraft	twelve 4.7" dual-purpose guns sixteen pom-poms eight 0.5" machine guns
torpedo	ten torpedo tubes in two quintuple mounts
aircraft	six and two catapults
Protection	
magazines	2,000-pound bomb 16" shellfire from normal battle ranges
machinery	1,000-pound bomb
underwater	750-pounds of TNT in contact with ship's side

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means, and technical factors tended to govern the decisions among alternatives within those limits.

The Admiralty was resolved to make an intense effort to have battleship size limited to 28,000 tons and main armament limited to 12-inch guns. To confirm the practicality of such a ship, a number of designs for 12-inch battleships were prepared in 1934. Noteworthy in these studies was the fact that to obtain a 28,000-ton standard displacement, a speed of only 23 knots could be attained, and the protection would be less than that called for in the Staff Requirements for the 1937 battleships. In any case, the pursuance of a 12-inch battleship design appeared doomed by developments in France and Italy in 1934. Both countries publicly announced their intention to construct 35,000-ton battleships armed with 15-inch guns. Moreover, Japan and the United States were also not in favor of constructing the smaller ships.

With the abandonment of the 12-inch battleship design, the Admiralty now was anxious to develop the particulars of the 1937 battleships in the face of new developments in Europe in 1934. The Germans were requesting relaxation of the Versailles Treaty so that they could rebuild their navy. In fact, in 1935 Great Britain hosted the first of two important naval conferences. In a conference with German representatives in June, an Anglo-German Naval Treaty was negotiated which permitted the Germans to build battleships. It was clear that the 35,000-ton standard displacement would remain as the basis for new battleship construction in the then foreseeable future. The hopes of also maintaining a slower speed for new construction also seemed doomed. The question of a balanced design between the needs of offense, defense, and speed became paramount and would be difficult to achieve without some compromises.

With the advent of the second London Conference, due to convene in 1935, and the need to define the particulars of the 1937 battleships, several studies of 14-, 15-, and 16-inch battleship designs were prepared, and variations were made in the speed and armor protection. Sixteen different designs were developed; Table 5-2 shows the characteristics of Designs 14A, 15A, and 16A that are considered representative of the designs considered at this early phase. All of these alternatives included the 4.5-inch dual-purpose gun in twin mounts, which reflected the new secondary armament being fitted to the reconstructed units of the *Queen Elizabeth* class. These designs were thoroughly reviewed as to their sufficiency in protection and speed. A range of 12,000 to 16,000 yards was outlined in the Battle Instructions as a decisive range of battleship gunfire, although there was some desire to permit a larger range (18,000-20,000 yards) to decrease the required armor protection. Nevertheless, the shorter range was chosen, and the ships were to be so protected against a 14-inch gun.

TABLE 5-2

King George V Class Preliminary Designs *

<i>Design</i>	<i>14A</i>	<i>15A</i>	<i>16A</i>
Displacement—tons (metric tons)			
Standard	35,000 (35,571)	35,000 (35,571)	35,000 (35,571)
Full load	40,390 (41,048)	40,390 (41,048)	40,390 (41,048)
Dimensions—feet (meters)			
Waterline length	770 (234.7)	770 (234.7)	770 (234.7)
Waterline beam	104 (31.7)	104 (31.7)	104 (31.7)
Draft (full load)	31.25 (9.52)	31.25 (9.52)	31.25 (9.52)
Armament			
Main	twelve 14"	nine 15"	nine 16"
Arrangement	3-3-A-3-3	3-3-A-3	3-3-A-3
HA/LA4.5"	20	20	20
2-pdr pom-pom	32	32	32
0.5" guns	16	16	16
Aircraft	4	4	4
Armor—inches (millimeters)			
Belt			
amidships	12.75 (324)	12.26 (311)	11.76 (298)
magazines	12.01 (305)	12.26 (311)	10.80 (275)
Turrets			
face	...	...	15.69 (396)
sides	...	...	10.80 (275)
rear	...	...	8.84 (224)
Decks			
amidships	3.33 (85)	4.17 (105)	2.94 (74)
magazines	4.90 (124)	5.16 (130)	4.90 (124)
Propulsion			
Speed (max)†	23	30	30
Shaft horsepower	65,000 (65,861)	112,000 (113,553)	112,000 (113,553)
Endurance, 14 knots	10,000	10,000	10,000
Weights—tons (metric tons)			
Outfit	1,200 (1,219)	1,200 (1,219)	1,200 (1,219)
Propulsion	1,950 (1,981)	2,875 (2,921)	2,875 (2,921)
Armament	8,150 (8,283)	6,270 (6,373)	7,160 (7,277)
Armor	11,325 (11,510)	11,155 (11,337)	10,075 (10,240)
Hull	12,375 (12,577)	13,500 (13,721)	13,690 (13,914)
Total stand. disp.	35,000 (35,571)	35,000 (35,571)	35,000 (35,571)
Fuel oil	4,000 (4,064)	4,000 (4,064)	4,000 (4,064)

* In the Royal Navy, the official standard used to design, order, and manufacture armor plate was its weight in pounds per square foot per inch thickness, actually some 40.8 pounds. For convenience, this measure was generally graduated in 10-pound increments. Since it was not necessary to know the precise thickness to the last decimal place, thicknesses were normally quoted by using the nominal 40 pounds per square foot per inch thickness. In this book, actual thicknesses have been calculated using the more exact conversion factor of 40.8. The correctness of the use of this factor was confirmed by Dr. Ian Buxton in visits to the *Vanguard* and various units of the *King George V* class while the ships were being broken up for scrap.

† At full-load displacement

The 30-knot speed was considered to be a liability for the protective requirements, and so a 3-knot reduction was recommended in Designs 15A and 16A. The 23-knot speed of the 14A design stemmed from the 12-inch battleship studies and also from the fact that this was the average speed of the battle fleet. In order to evaluate the effect of speed in the 14-inch designs, three more designs (14C, 14D, and 14E) were prepared (see Table 5-3).

TABLE 5-3

King George V Class Preliminary Designs (19 August 1935)

<i>Design</i>	<i>14C</i>	<i>14D</i>	<i>14E</i>
Displacement—tons (metric tons)			
Standard	35,000 (35,562)	35,000 (35,562)	35,000 (35,562)
Full load	40,390 (41,048)	40,390 (41,048)	40,390 (41,048)
Dimensions—feet (meters)			
Waterline length	770 (234.7)	770 (234.7)	770 (234.7)
Waterline beam	104 (31.7)	104 (31.7)	104 (31.7)
Draft (full load)	31.25 (9.52)	31.25 (9.52)	31.25 (9.52)
Armament			
14"/45	12	8	10
Arrangement	3-3-A-3-3	2-2-A-2-2	3-2-A-2-3
HA/LA4.5"	20	20	20
2-pdr pompom	32	32	32
5" (50 cal.) guns	16	16	16
Aircraft	4	4	4
Armor—inches (millimeters)			
Belt			
amidships	10.80 (275)	12.75 (324)	12.26 (331)
magazines	11.76 (298)	13.73 (348)	12.26 (311)
Turrets			
face	11.76 (298)	11.76 (298)	11.76 (298)
sides	8.84 (224)	8.84 (224)	8.84 (224)
rear	7.35 (187)	7.35 (187)	7.35 (187)
Decks			
amidships	3.33 (85)	4.90 (149)	5.14 (131)
magazines	4.90 (124)	6.13 (156)	5.14 (131)
Propulsion			
Speed (max)*	29	29	29
Shaft horsepower	112,000 (113,553)	112,000 (113,553)	112,000 (113,553)
Endurance, 14 knots	10,000	10,000	10,000
Weights—tons (metric tons)			
Outfit	1,200 (1,219)	1,200 (1,219)	1,200 (1,219)
Propulsion	2,875 (2,921)	2,875 (2,921)	2,875 (2,921)
Armament	6,860 (6,970)	5,200 (5,283)	6,060 (6,706)
Armor	10,525 (10,694)	12,305 (12,503)	11,395 (11,579)
Hull	13,540 (13,758)	13,400 (13,615)	13,470 (13,686)
Total stand. disp.	35,000 (35,562)	35,000 (35,562)	35,000 (35,562)
Fuel oil	4,000 (4,064)	4,000 (4,064)	4,000 (4,064)

* At full-load displacement

It was clear from these early studies that it was not possible to design a ship armed with either nine 16-inch or twelve 14-inch guns and with a speed of 30-knots and a 35,000-ton standard displacement. It was possible, however, with some compromises, to design a 30-knot ship armed with nine 15-inch guns. For the slower speeds of 27 and 23 knots, the larger calibers of 15- and 16-inch guns were preferred. The number of guns, however, was also an important consideration, and it was possible to have more 14-inch guns for a given displacement without any reduction in speed or protection. For example, while it was possible to have nine 16-inch guns on a 23-knot battleship, twelve triple turrets of 14-inch guns could also be achieved for the same displacement and speed.

Three early 14-inch fast-battleship designs were completed by 19 August 1935 with Design 14C featuring an emphasis on armament, Design 14D featuring an em-

TABLE 5-4
King George V-Class Design Studies

	Design	14F	14L	14-O	14P
Date		9 Sept. '35	11 Nov. '35	6 Mar. '36	3 Apr. '36
Displacement—tons (metric tons)	Standard	35,000 (35,562)	34,900 (35,461)	35,450 (36,019)	35,450 (36,019)
	Full load	...	...	40,840 (41,495)	40,840 (41,495)
Dimensions—feet (meters)					
Length w.l.		740 (225.6)	740 (225.6)	740 (225.6)	740 (225.6)
Beam w.l.		104 (31.7)	104 (31.7)	104 (31.7)	104 (31.7)
Draft*		31.25 (9.52)	31.5 (9.60)	31.5 (9.60)	31.5 (9.60)
Armament					
14"/45 guns		12	12	12	10
Arrangement		4-4-A-4	4-4-A-4	4-4-A-4	4-2-A-4
5.25" guns		none	none	16	16
4.5" guns		20	20	none	none
2-pdr. pom-poms		32	32	32	32
5" mach. guns		16	16	16	16
Aircraft		4	4	4	4
Armor—inches (millimeters)					
Belt					
amidships		11.76 (298)	12.75 (324)	12.75 (324)	13.73 (348)
magazines		12.75 (324)	13.73 (348)	13.73 (348)	14.71 (372)
Turrets					
face		11.76 (298)	12.75 (324)	12.75 (324)	12.75 (324)
side		8.84 (224)	8.84 (224)	8.84 (224)	8.84 (224)
rear		7.35 (107)	6.86 (174)	6.86 (174)	6.86 (174)
Deck					
amidships		3.92 (100)	4.90 (124)	4.42 (112)	4.90 (124)
magazines		5.88 (149)	5.88 (149)	5.38 (134)	5.88 (149)
Propulsion					
Speed (max)*		26	27	27.5	27.5
Shaft horsepower		80,000 (81,110)	100,000 (101,387)	100,000 (101,387)	100,000 (101,387)
Endurance, 14 knots		14,000	14,000	14,000	14,000
Weights—tons (metric tons)					
Outfit		1,200 (1,219)	1,050 (1,067)	1,050 (1,067)	1,050 (1,067)
Propulsion		2,375 (2,413)	2,550 (2,591)	2,635 (2,677)	2,635 (2,677)
Armament		6,860 (6,970)	6,550 (6,655)	6,650 (6,757)	5,880 (5,974)
Armor		11,365 (11,548)	11,800 (11,990)	12,050 (12,244)	12,845 (13,052)
Hull		13,200 (13,412)	12,950 (13,158)	13,065 (13,275)	13,040 (13,250)
Total†		35,000 (35,562)	34,900 (35,461)	35,450 (36,019)	35,450 (36,019)
Fuel oil		4,000 (4,064)	4,000 (4,064)	4,000 (4,064)	4,000 (4,064)

* Full-Load Displacement

† Standard Displacement

Thicknesses for armor protection are maximum figures.

phasis on protection, and Design 14E being a compromise between the armor and armament of Designs 14C and 14D. The technical division of the naval staff evaluated these and thirteen other preliminary battleship designs of varying speeds, protection, and armament. High points of their evaluation were:

- Design 16A—Extremely vulnerable to plunging shells and bombs, particularly because of her 3-inch deck—considered overgunned for a 30-knot ship of 35,000 tons.

- Design 15A—Weak protection against 16-inch shellfire at battle ranges of 12,000-16,000 yards, but because of heavier protection, was considered a better balanced design than 16A.
- Design 14C—Overgunned for a 30-knot speed and lacked the protection for a battle range of 12,000-16,000 yards.
- Design 14D—Good protection at ranges sought, but with eight 14-inch guns lacked sufficient offensive power.
- Design 14E—Could not stand in a battle line at 12,000-16,000 yards without grave risk, but could contribute usefully at approximately 19,000 yards against 15-inch and 16-inch shellfire.

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Another 14-inch design (14F) was prepared for the evaluation of the naval staff. This 35,000-ton design featured a 27-knot speed and quadruple mounting of the main armament in an attempt to reduce the armor-box length, ship size, and the number of gun positions to three instead of four. In its evaluation of the design the technical division of the naval staff concluded:

As compared with the "16A", "14F" has a valuable superiority in deck protection. She should obtain four 14-inch hits at useful ranges for every three 16-inch hits by her opponent. "16A" will gain an advantage at 18,500 yards by being able to pierce the belt of "14F" 1,000 yards before her own belt can be pierced by 14-inch shells. "14F" will be better able to stand in line than "16A." Against "15A" similar remarks apply except that "14F" has not in this case so great an advantage in deck protection, but she is able to close to a more effective range for bringing her high volume of fire to bear. It would appear that "14F" is as powerful as "16A" or "15A," and she has an asset in her good decks and torpedo bulkhead.

On 20 September 1935 a review was made by the Sea Lords of the technical evaluation of the designs. It was concluded that the 1937 battleships should be armed with nine 15-inch guns in three triple turrets and attain a speed of not less than 29 knots.

In the meantime, designs of 14-inch and 16-inch battleships were also being prepared in the United States. In October 1935, several months before the convening of the 1936 London Naval Conference, the United States indicated that it was willing to accept a 14-inch limit, providing that Japan would go along. Oral instructions were given by Admiral William H. Standley, acting American Secretary of the Navy, to the Bureau of Construction and Repair to proceed with designs for a ship to carry three quadruple 14-inch turrets, which could be altered at a later time to take three 16-inch triple mountings. This was basically the American version of the 1937 battleships that would become the *North Carolina* and *Washington*.

The American decision to proceed with a 14-inch battleship design resulted in the Admiralty rescinding its decision regarding the 15-inch battleship. To have a battleship commissioned in the Royal Navy by 1940, however, it would be necessary to place orders for the guns and mountings by the end of 1935 so that their design could commence immediately. On 10 October the Sea Lords met again and decided to recommend that the 1937 battleships be based on a 35,000-ton displacement, mount twelve 14-inch guns in three quadruple turrets, and achieve a speed of 26 knots. The Board of the Admiralty and the Cabinet later concurred on this decision. On 11 November design work on Design 14L was completed and submitted to the controller on the next day.

After Design 14L had been reviewed, the Director of Naval Construction, Sir Stanley Goodall, was requested to study an alternative design that would feature a single funnel. The machinery would be concentrated farther aft than 14L, thereby

reducing the shafting lengths, while the 4.5-inch mountings would be concentrated in a battery forward of these spaces. Although the design (14N) was prepared, there was extreme difficulty in arranging air intakes and exhausts from the boiler rooms. The *Centurion*, a target ship, was later equipped with a mock-up of the single funnel arrangement and tested. The shells defeated the protection employed, but, more importantly, the intake fans drew fumes down into the boiler room, putting it out of action. It was decided, therefore, to use the two-funnel arrangement of Design 14L.

Some consideration also was given to a three-engine-room arrangement in this early design. It had no advantage from a propulsive viewpoint, except that the center shaft would have been better placed from the point of view of damage from contact torpedoes. Also, it was thought that this arrangement lessened the impact of shafting passing through the underwater protection system outboard of an after turret in a region of the ship where the beam begins to decrease. At the conclusion of the investigation, it was determined that a three-shaft arrangement was not possible with a quadruple turret aft. Such an arrangement was used in the aircraft carrier *Ark Royal*, however, where the turret problem did not exist, and severe vibration problems were encountered during this carrier's operation.

Designs 14L and 14N were reviewed at a meeting of the Sea Lords on 2 January 1936. Although the design featuring the single funnel was favored by the assistant chief of the naval staff and the controller, the difficulties with the intake and uptake design were noted. Authorization was also given to test the concept on the *Centurion* cited previously. Other important points of discussion were:

- **Speed**—The design speed of 28 knots in the standard condition would be reduced 1 knot in the full-load condition. Some 2,000 tons of water was being carried to make the side protection system effective, and it was suggested that this water be replaced by fuel oil.
- **Secondary armament**—A new 5.25-inch mount had been proposed for the new *Dido*-class anti-aircraft cruisers, and it was suggested by the First Sea Lord to substitute these for the 4.5-inch guns in Designs 14L and 14N. The Director of Naval Ordnance was called in to discuss the 5.25-inch gun program, since the design of this gun had not yet commenced and would not be completed until late 1936 at the earliest. Therefore, he was reluctant to recommend its inclusion in the new battleship design. However, the First Sea Lord recognized the problem in such a weapon's development and decided to proceed with the substitution of the 5.25-inch gun for the 4.5-inch, citing that by 1940 all problems should be resolved.
- **Armor**—A proposal was made to raise the belt and deck armor from the middle to the main-deck level. This would increase the armor freeboard and reserve buoyancy while providing a reduction in areas of the hull subject to damage.
- **Boilers**—The Directors of Engineering proposed that a 100-ton weight margin be included in the weights for the propulsion plant for possible future increase in boiler horsepower.

As a result of this meeting, a new design (14-0) was prepared by 6 March 1936 (see Table 5-4). The most difficult problem was in the armor arrangement. To gain the extra belt-armor protection and yet provide sufficient stability, the deck armor had to be reduced. This design caused some concern within the Admiralty as to its suitability, since the reduced deck armor increased the vulnerability of the magazines and machinery to bomb and shell attack. Also, the arrangement of the heavier 5.25-inch battery and the pom-pom and 0.5-inch machine-gun battery was too congested and subject to the blast effects of the larger secondary guns.

The naval staff was not happy with the protection of Design 14-0, and several alternatives were proposed for a possible reworking of its preliminary design to achieve an upgrading in the protection. The following suggestions were made:

- Place the armor deck at the middle deck and increase the deck armor thickness to 5.88 inches over the magazines and 4.90 inches over the machinery. This would decrease the vulnerability of the ship to shell and bomb attack.
- Decrease the speed of Design 14-0 to 25 knots and shorten the ship.
- Reduce the armament to nine 14-inch guns in triple turrets.
- Change the armament to nine 15-inch guns in triple turrets.
- Separate the 5.25-inch guns into separate fore-and-aft batteries of four mounts each.

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To complicate matters, the torpedo protection system had to be increased to withstand attack by a torpedo with a 1,000-pound TNT charge instead of the 750 pounds specified in the Staff Requirements. It became apparent that a reduction in the 14-inch armament might be a compromise solution to the protection problem. Although the 12-gun armament was preferred, the speed and protection requirements could not be achieved in a 35,000-ton displacement. As a result, Design 14P (Table 5-4) was prepared with the initial intent of carrying nine 14-inch guns; however, the design of a quadruple turret was well advanced. To save time in the delivery of the ships, it was thought prudent to alter one turret to a twin and thoroughly investigate the weights for design 14L for possible overestimates.

During April 1936 the Board of the Admiralty met to decide on the characteristics of the 1937 battleships—twelve or ten 14-inch guns. Majority opinion was that the twelve 14-inch gun design, although preferable, would not yield the protection or speed deemed necessary for the new 35,000-ton ships. It was decided to accept Design 14P as the basis for the new design, accepting the delays in production that would accrue for the development of the twin turret.

Weight reduction was still necessary. Armor weights were cut by reducing deck heights and freeboard. Reducing the upper deck sheer forward to five feet enabled "A" turret to fire directly forward at a zero-angle of elevation. This avoided raising "B" turret and the bridge, and saved some weight in the barbette armor and structure. The reduced freeboard and limitation of sheer forward made the ships wet in a seaway and worsened living conditions. The final designs well exceeded 35,000 tons standard displacement, thus further reducing freeboard. Before contracts were signed, an effort was made to reduce displacement, which had been increased in Design 14P by changes in armor weight. Early in the preliminary design much consideration had been given to the beam and draft of these vessels. One important restriction was the limit on the beam of 104 feet, for docking at Portsmouth and Rosyth. This made the provision of adequate underwater protection and stability very difficult, and thirty-seven beam-draft combinations were studied before an acceptable solution was found. In the development of the final design, the beam was reduced one foot, which reduced structural weight and the extent of the heavy armor deck. This beam reduction reduced the stability (GM). Nevertheless, British naval constructors did not deem the latter serious, because it was believed that even with the beam change there was enough residual GM in case of damage.

On 28 May 1936 approval was given by the Board of the Admiralty to the sketch design known as "14P", and the final design work progressed through the summer of 1936. On 29 July 1936, two ships, the *King George V* and *Prince of Wales*, were officially ordered in the 1936 Program. The board drawings were completed, approved,

TABLE 5-5

King George V Class Final Contract Design

Standard displacement	35,490 tons (36,060 mt)
Full-load displacement	40,580 tons (41,231 mt)
Waterline length	740' (227.1 m)
Waterline beam	103' (31.3 m)
Draft (standard)	28' (8.53 m)
Draft (full load)	31.5' (9.6 m)
Armament	ten 14"/45—one paired and two quads. sixteen 5.25"/50 (Mark 1) dual-purpose twin (134-mm). thirty-two 2-pdr. Mark VI quadrupled (40.5 mm) sixteen 0.5" quadrupled (12.7 mm) four aircraft
Shaft horsepower	100,000 (101,387 mhp)
Maximum speed	27.5 knots
Endurance	14,000 miles at 14 knots
Fuel oil	3,700 tons (3,759 mt)
Immunity zones	against 1,938-lb (879 kg), 15" (381-mm) shell: magazines—17,000-32,000 yards (15,728-29,261 m) machinery—19,500-28,000 yards (17,831-25,603 m)
Bomb protection	deck armor to be proof against 1,000-lb. (454-kg) bomb dropped from 3,500 feet (1,067 meters).
Torpedo protection	side protection system to resist a 1,000-lb. (454-kg) TNT charge.

and delivered to the shipbuilders on 30 September 1936. The final contract design characteristics of the *King George V* class are summarized in Table 5-5.

Before construction commenced, the final weight report showed a 400-ton increase in the standard displacement, making the full-load displacement 40,980 tons. Every effort was made during design and construction to economize in weight. Subsequently, when treaty restrictions lapsed with the declaration of war in 1939, protection, armament, and fire-control systems were improved at the cost of weight. The accepted full-load displacement, based on the inclining experiment of the *King George V*, was 42,245 tons. The *Anson*, after her 1944 refit, had a full-load displacement of 45,360 tons and a maximum draft of 34.83 feet. Increased compartmentation, armament changes, radar, increased complement, and more fuel were the chief causes for these large increases in full-load displacement. Finally, in 1947, the commanding officers of *King George V*-class ships were informed that a draft of 34.67 feet, which corresponded to a displacement of 45,000 tons, could not be exceeded.

The *King George V* class was designed to comply fully with the limitations of the 1936 London Treaty. There was a provision, however, that would permit a 16-inch main battery if Italy and Japan had not signed the treaty by 1 April 1937. Consideration was given to designing the ships to permit a change-over from 14-inch quadruple to 16-inch triple mountings if Japan failed to agree to the 14-inch gun, but it was determined that this would have involved an appreciable increase in the citadel length and armor weight plus an appreciable delay in the design and production of new 16-inch turrets. It was decided to design for 14-inch guns only.

In October discussions began on the three ships to be ordered under the 1937 program. Because of the treaty limitations and the gun-mounting design and production problems, it was decided that these ships be repeats of the 1936 program. The Board of the Admiralty concurred and approved the recommendation on 16 November 1936. These ships were named as follows:

- *King George V*
- *Prince of Wales*
- *Duke of York* (ex-*Anson*)
- *Anson* (ex-*Jellicoe*)
- *Howe* (ex-*Beatty*)

Although ordered in different years, they were often called the battleships of the 1936 program. The *King George V* and *Prince of Wales* were laid down in January 1937, followed by the *Duke of York* in May, the *Howe* in June, and the *Anson* in July.

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Prince of Wales—Operational History.* The keel of the *Prince of Wales* was laid at Cammell Laird Shipyard in Birkenhead on 1 January 1937; the ship was launched on 3 May 1939. When war was declared in September, she was fitting out. Her construction schedule and that of the *King George V* were accelerated, but the late delivery of the gun mountings caused delays in her outfitting. During early August 1940, while still in a semicomplete state with her main turrets yet to be fitted and compartments not sealed, she was attacked by German aircraft.

Bomb damage. One bomb fell between the ship and a wet basin wall, narrowly missing a 100-ton dockside crane, and exploded underwater below the bilge keel. The explosion took place about six feet from her port side in the vicinity of the after group of 5.25-inch guns. Buckling of the shell plating took place over a distance of 20 to 30 feet, rivets were sprung, and considerable flooding took place in port outboard compartments in the area of damage, causing a ten-degree port list. The flooding was severe, due to the fact that final compartment air tests had not yet been made, and the ship also did not have its pumping system in operation. With the joint effort of a local fire company and the shipyard, the water was pumped out and the vessel was later drydocked for permanent repairs. This damage and problems in the deliveries of her main guns and turrets delayed her completion. As the war progressed, there was an urgent need for the *Prince of Wales*, and so her completion was advanced by postponing compartment air tests, ventilation tests, and a thorough testing of her bilge, ballast, and fuel-oil systems. The ship was completed on 31 March 1941, and trials were held on 8 May 1941. The usual policy of returning the ship to the builder's yard for two or three months for the correction of problems occurring during trials was waived. By 10 May 1941 the *Prince of Wales* was in Scapa Flow for gunnery practice. The Admiralty was anticipating the Germans would be deploying the *Bismarck*, and there was need for her in case this should happen. Therefore, workmen from Cammell Laird assisted the crew in Scapa Flow in conducting compartment air tests, but there is no indication that pumping and ventilation tests were ever completed. Also, since the turrets were of a new design, subject to frequent interlock failures and other mechanical defects, the ship carried a Vickers Armstrongs civilian technician for each turret.

Action with Bismarck. On 22 May 1941, the *Prince of Wales*, the *Hood*, and six destroyers were ordered to take station south of Iceland and intercept the German battleship *Bismarck* if she attempted to break out into the Atlantic. Captain John Leach knew that main-battery breakdowns were likely to occur, since Vickers

* The *Prince of Wales* appears first in the narratives to aid in the description of the *Bismarck* episode.



The Prince of Wales, while fitting out at the Cammell Laird Shipyard, was damaged by a near-miss bomb in August 1940. The top view shows the dished shell plating—note the plugs in way of popped rivets. The bottom view shows the internal deformation in the area of the damage shown above and is typical of a compartment in a side protection system. (Royal Navy, HMS Excellent)

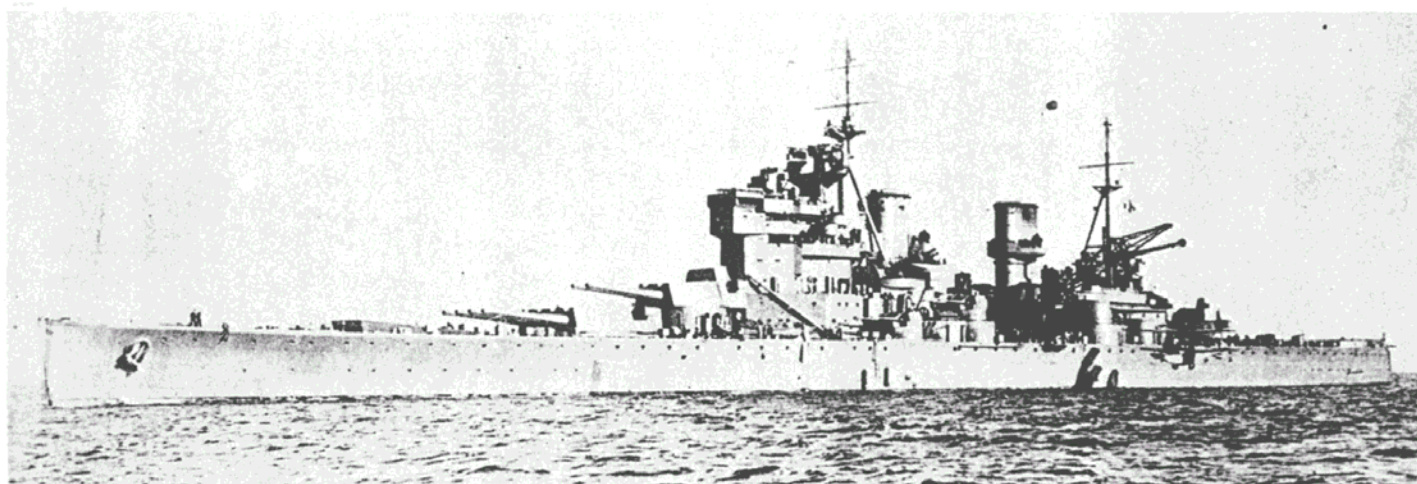
Armstrong's technicians had already corrected some that took place during training exercises in Scapa Flow. These technicians were personally requested by the captain to remain aboard. They did so and played an important part in the resulting action.

The next day the *Prinz Eugen* and *Bismarck* were reported heading southwestward in the Denmark Straits. At 2000 Vice Admiral Lancelot E. Holland, in the flagship *Hood*, ordered the force to steam at 27 knots, which it did most of the night. His battle plan called for the *Prince of Wales* and *Hood* to concentrate on the *Bismarck*, while the cruisers *Norfolk* and *Suffolk* would handle the *Prinz Eugen*, but the two cruisers in the Denmark Straits were not so informed due to strict radio silence.

At 0200, 24 May 1941, the destroyers were sent as a screen to search for the German ships to the north, and at 0247 the heavy ships increased speed to 28 knots and changed course slightly to obtain a better target angle on the German ships. The weather improved, with ten-mile visibility, and crews were at action stations by 0510. At 0537 an enemy contact report was made, and course was changed to starboard to close range. Neither ship was in good fighting trim. The *Hood*, designed twenty-five years earlier, lacked adequate horizontal protection and would have to close the range quickly, as she would become progressively less vulnerable to plunging shellfire at shorter ranges. She had completed an overhaul in March, and her crew had not been adequately retrained. The *Prince of Wales*, with thicker armor, was less vulnerable to 15-inch shells down to 17,000 yards, but her crew, too, had not been trained to battle efficiency.

The British ships made their last course change at 0549, but they had made their approach too fine (the Germans were only 30 degrees on the starboard bow), and their after turrets could not fire. The *Prinz Eugen*, with the *Bismarck* astern, had the British slightly forward of the beam and both ships could deliver full broadsides. At 0553, despite seas breaking over bows, the *Prince of Wales* opened fire on the *Bismarck* at 20,000 yards. There was some confusion among the British as to which ship was the *Bismarck*, and thirty seconds earlier the *Hood* had mistakenly opened fire on the *Prinz Eugen*. The *Hood*'s first salvo was a straddle, but the *Prinz Eugen*, in less than three minutes, scored 8-inch-shell hits on the *Hood*. The first shots by the *Prince of Wales*—two three-gun salvos at ten-second intervals—were 1,000 yards over. The

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The *Prince of Wales* a few days before her engagement with the German battleship *Bismarck* and the heavy cruiser *Prinz Eugen* in the Denmark Straits. Despite some serious damage caused by the Germans' shellfire, the *Prince of Wales* hit the *Bismarck* three times, leading to the German decision to modify their plans and head for France. The famous chase ended with the interception and destruction of the German battleship on 27 May 1941.

turret rangefinders could not be used due to spray over the bow, and fire was directed from the 15-foot rangefinder in the control tower. The third or fourth salvo was a straddle, and about that time two decisive hits were made on the *Bismarck*. One shell holed her bow and caused the loss of 1,000 tons of fuel oil, mostly due to saltwater contamination. The other fell short, entered the ship below the side armor belt, exploded, flooded the boiler auxiliary machinery room, and forced the shutdown of two boilers due to a slow leak in the boiler room immediately aft. The loss of fuel and boiler power were decisive factors in the decision that the *Bismarck* return to port. In the *Prince of Wales*, "A" turret ceased fire after the first salvo due to a defect.

After a brief lull, fire continued with three guns, but sporadic breakdowns occurred until the decision to turn away was made. At this time "A" turret was jammed.

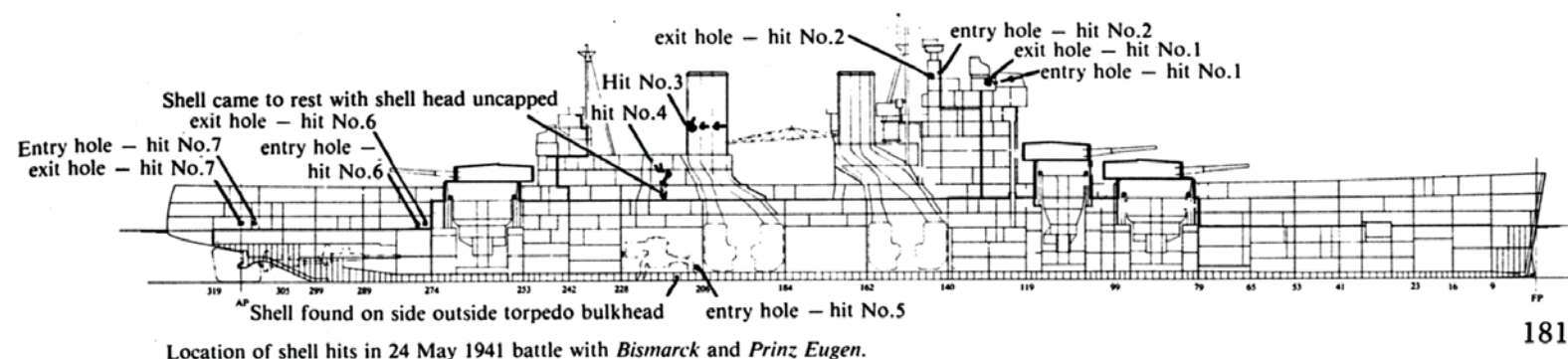
Both German ships initially concentrated their fire on the *Hood* and destroyed her with salvos of 8- and 15-inch shells. An 8-inch hit on the boat deck struck a ready service locker for the UP rocket projectors, and a fire blazed high above the first superstructure deck. At 0558 at a range of 16,500 yards, the force commander ordered a turn of 20 degrees to port to open the range and bring the full battery of the British ships to bear on the *Bismarck*. As the turn began, the *Bismarck* straddled the *Hood* with her third and fourth four-gun salvos, and at 0601 the fifth salvo hit, causing a large explosion. Flames shot up near the *Hood*'s masts, then an orange-colored fireball and an enormous smoke cloud obliterated the ship. On the *Prince of Wales*, it seemed that the *Hood* collapsed amidships, and the bow and stern could be seen rising as she rapidly settled. The *Prince of Wales* made a sharp starboard turn to avoid hitting the debris, and in doing so further closed the range between her and the German ships. In the four-minute action, the *Hood*, the largest battlecruiser in the world, had been decisively defeated and sunk, with the loss of all but three of her crew of 1,419 officers and men.

Shell damage. The *Prince of Wales* fired unopposed until she began a port turn at about 0557, when the *Prinz Eugen* took her under fire. After the *Hood* exploded at 1601, the Germans opened intense and accurate fire on the *Prince of Wales*, with 15-inch, 8-inch, and 5.9-inch guns. A heavy hit was sustained below the waterline as the *Prince of Wales* maneuvered through the wreckage of the *Hood*. At 0602, a 15-inch shell struck the starboard side of the compass platform and killed the majority of the personnel there. The navigating officer was wounded, but Captain Leach was unhurt. Casualties were caused by the fragments from the shell's ballistic cap and the material it dislodged in its diagonal path through the space.

The point of first impact was on a curtain plate, which was destroyed over an area 24 inches long by 8 inches high (see Figure 5-1 and 5-2). The axis of the shell was at the lower edge of the curtain plate and was 46 inches abaft the forward end. The majority of the curtain plate over the area destroyed was forced back in the form of petals which curved upward with their free ends lodged in the balsa-wood sheathing on the underside of the roof. Small fragments were dislodged and ricocheted about in the enclosed compass platform.

The shell passed on and perforated the port after corner. The lower edge of the damaged structure was 2.58 feet above the compass platform. Above this the door support was destroyed for a depth of 2.5 feet and the bridge side plating was torn outwards about the forward and lower edges. Damage to the bridge roof and curtain plate was slight.

Fortunately, the shell did not explode, but in its passage out of the enclosed compass platform, it tore a hole 2.5 by 2.0 feet in the shell plating, destroyed a 44-inch searchlight control, and passed through the port bulwark. All equipment, instruments, and wiring in the way of the shell's trajectory were destroyed or damaged.



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Figure 5-1. Inboard Profile Showing Shell Hits—Prince of Wales

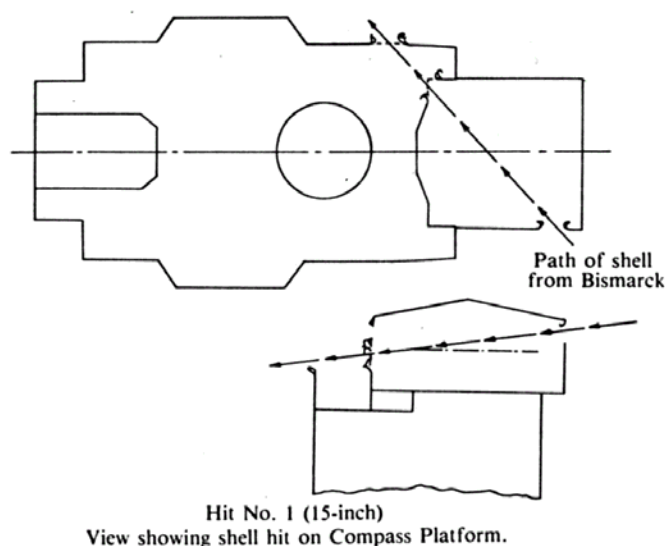


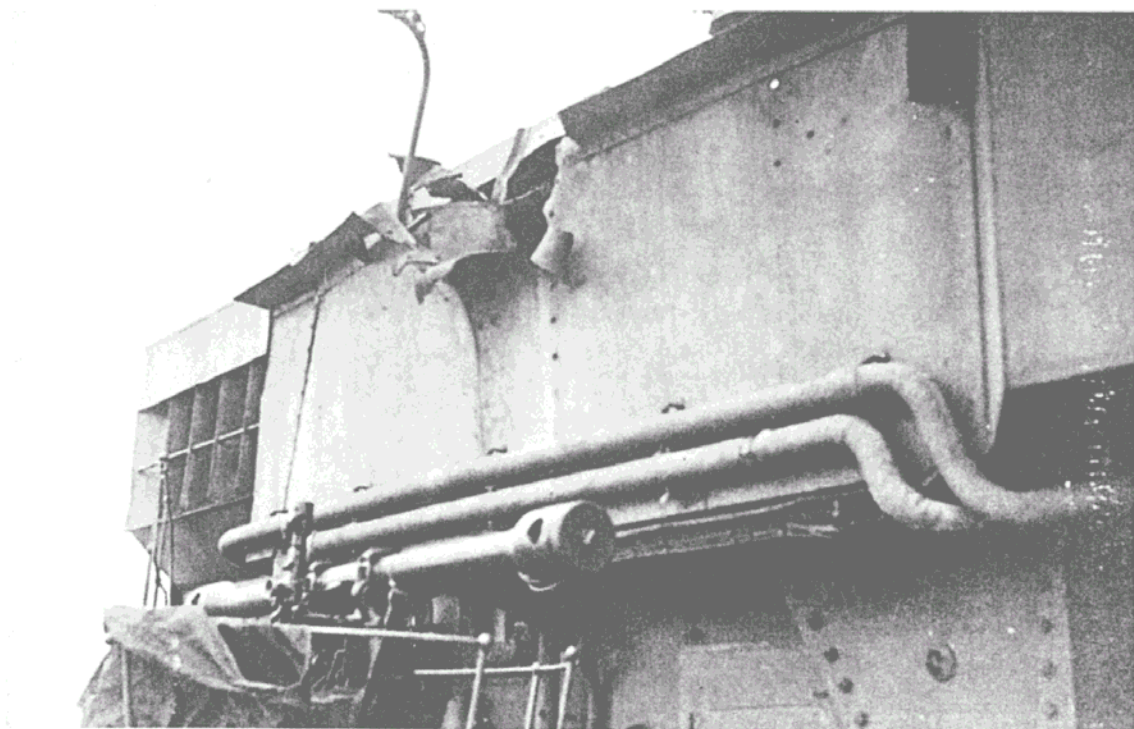
Figure 5-2. Bridge Damage—Prince of Wales

Telephone leads and communication to steering were severed, important bridge personnel were killed, and there was some damage to control instruments and communications.

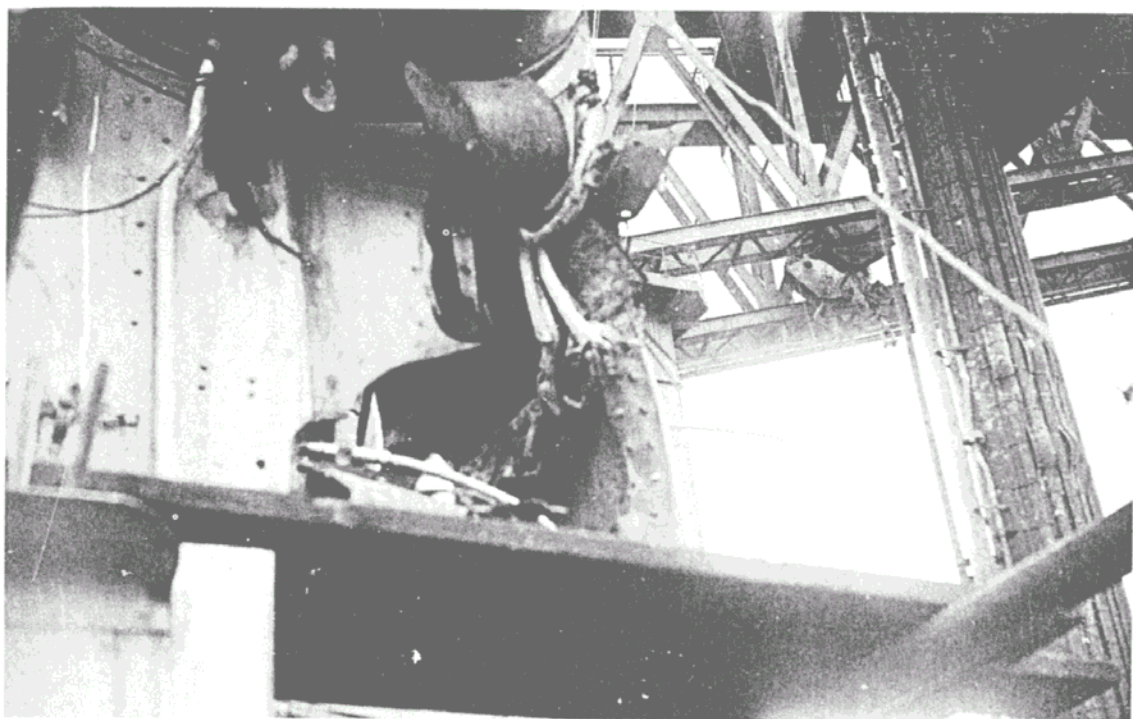
Around 0602 the foundation for the forward director for the 5.25-inch guns was struck (see figure 5-3), cutting all leads to the port director in train.

The shell entered the support for the 5.25-inch director through a circular hole on the forward starboard side. It struck the overhead in the admiral's charthouse, and was deflected upwards, passing out the side without exploding. There was considerable dishing and tearing of plate in the shell's track. Hot-water and fresh-water gravity tanks suspended above the charthouse were destroyed, and the flood of hot water caused a considerable problem on the bridge until the supply could be shut off. The contents of the admiral's charthouse and the echo-sounding gear were destroyed. Control of all 5.25-inch mounts was shifted to the after director, but another 15-inch hit on the boat deck seriously interfered with this director.

The shell which struck the director foundation set down the roof of the admiral's charthouse a maximum of 22 inches at the port forward corner. A hole three-feet long and four-feet wide was torn in the roof, and the plating was bent down about its inner edge (12 inches) into the charthouse roof. The shell passed out through the outer longitudinal bulkhead and made a hole some 3.5-feet long and 4.5-feet high.



The shell hit on the enclosed compass platform of the Prince of Wales from a 15-inch shell from the Bismarck is viewed from outside the ship, showing the exit hole in the port bridge bulwark plating. Absence of splinter damage indicates that the shell did not burst near the ship. This was the first shell hit. (Royal Navy, HMS Excellent)



This view shows an exit hole in the port side plating of the 5.25-inch gunfire control director. The shell was probably an 8-inch from the Prinz Eugen; however, there is a slight possibility that it could have been a 15-inch. (Royal Navy, HMS Excellent)

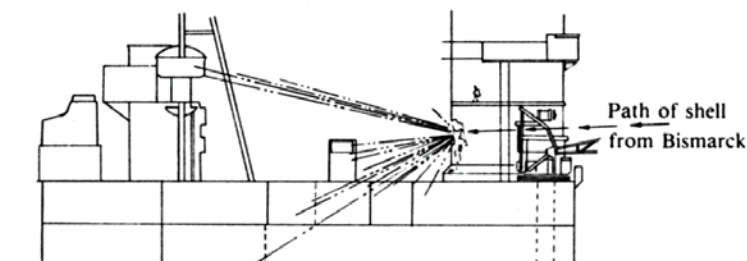
The forward side of the structure in the vicinity of the lightning hole was bulged slightly forward. The door at the port forward corner was forced open against its seating, and a ladder adjacent to it was distorted. One large piece of structure severed a vertical bar of the ladder and made a hole 18 by 9 inches in the outer bulkhead.

The director support was distorted and the starboard director was jammed temporarily in train. There were no other mechanical failures. Electric leads and junction boxes to the port director were severed and the leads were replaced by temporary wiring rigged by the ship's crew in little more than twenty-four hours.

The shell that destroyed the admiral's charthouse and struck the forward starboard director was first thought to have been a 15-inch, as it could have been part of the same salvo that hit the compass platform; however, there is some conflicting data on the true caliber of this particular shell. It might have been only an 8-inch, because the damage was not consistent with a 15-inch shell (a heavy caliber shell would not have been so easily deflected by the charthouse structure), and the bearing and angle of descent were not consistent with those of the previous hit.

The shell traveled 8.5 feet in the ship, encountering no serious obstacles. As a result of this hit, the port 5.25-inch director was permanently out of action with the starboard director temporarily out of action.

A 15-inch shell hit the post of the airplane and boat crane (see figures 5-3 and 5-4), was deflected, and exploded abaft the second funnel. It ripped a three-by five-foot hole in the funnel plating and showered much of the boat deck with splinters. Shell fragments riddled the wings of a Walrus seaplane about to be launched, and the plane was catapulted overboard. The inboard controls for the crane were destroyed and the crane was put out of action.



Hit No.3 (15") showing fragment spray from bursting shell on adjacent structure.

Figure 5-3. Damage to Airplane Crane and After Funnel

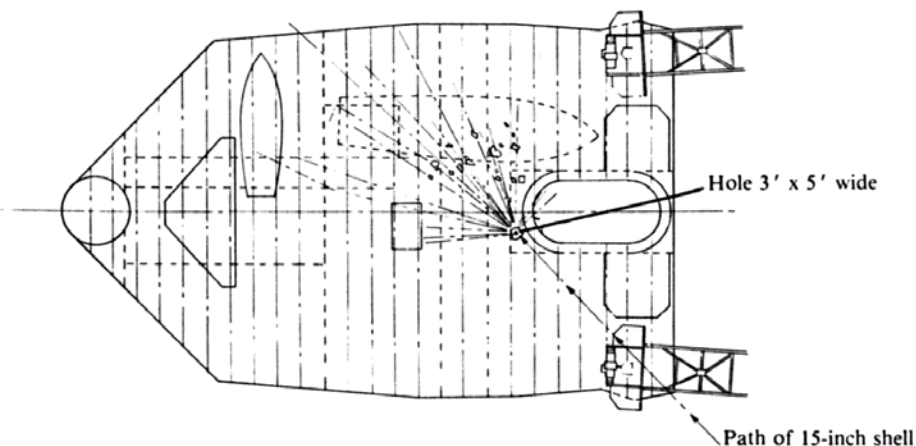
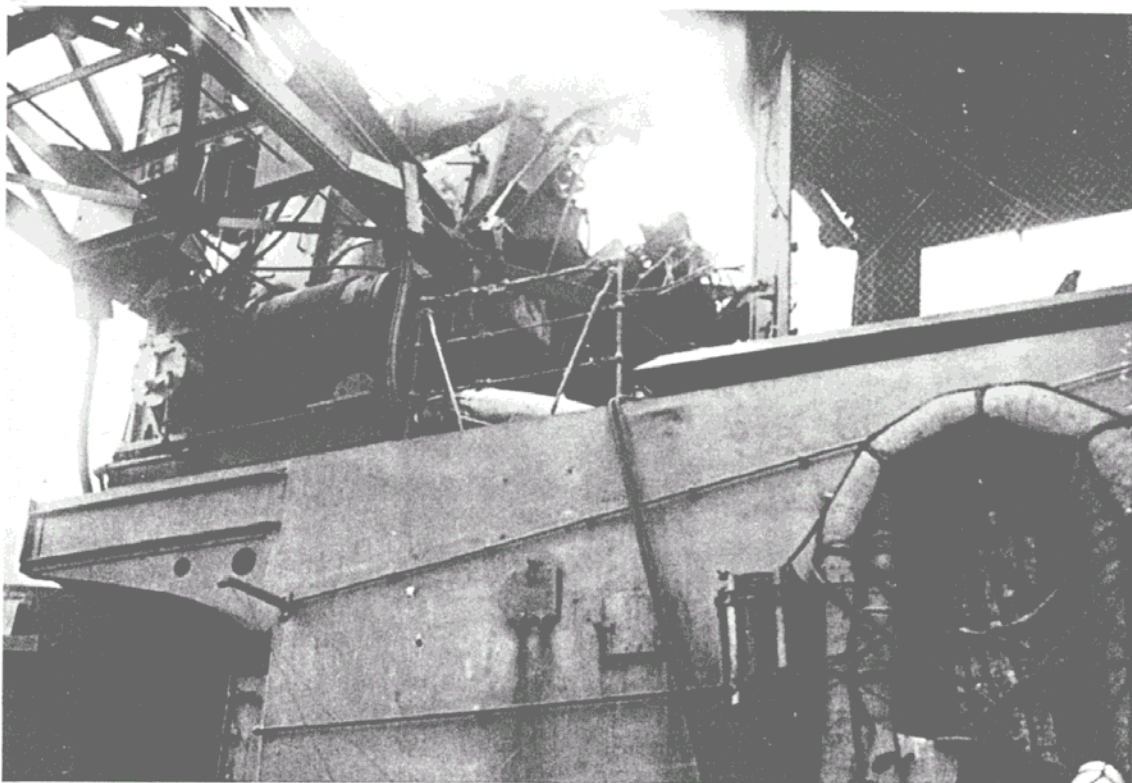


Figure 5-4. Plan View of Damage to Airplane Crane and After Funnel



Two vivid views of the damage caused by a shell which struck the starboard aircraft crane and exploded above the boat deck abaft the rear funnel, wrecking the crane and riddling the boat deck in the area of the burst with thirty-seven holes from the shell splinters. (Royal Navy, HMS Excellent)

The shell struck the starboard aircraft crane, which was stowed fore and aft in the vicinity of the inboard controls. The position of impact was approximately ten feet above the boat-deck level on the inboard side of the structure on top of the crane post. The post was set down and caused the upper deck to dish over an area about 3.5 feet in diameter. The maximum dish was 0.5 to 0.75 inches and was augmented by a local depression in the center. This latter was caused by a piece of structure supported on the top of the post being projected downwards inside the post at high velocity. While passing down the post, it damaged an interior angle bar stiffener at the level of the boat deck.

After striking the aircraft crane, the shell was deflected upwards and burst some 9.5 feet above the boat deck and 4.0 feet to starboard of the ship's centerline. Splinters were showered over the boat deck as far away as 57 feet from the point of the explosion and caused severe splinter damage to this deck over an area of some 20 square feet. There were at least thirty large splinter holes in the boat deck with the largest individual hole being some two square feet. A large number of splinters passed through the funnel and caused damage on the port side. These splinters caused damage to the port side of the engine-room exhaust and to minor equipment on the forward side of the after superstructure. Four splinters from the burst also entered the port after 5.25-inch director and severely wounded one of the crew.

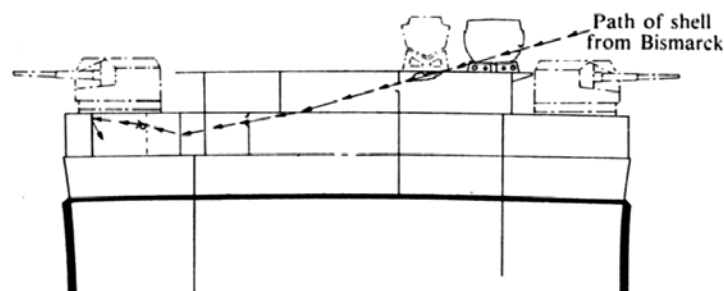
A number of boats stowed in the area of the burst were severely damaged; two were completely destroyed, two others were badly damaged, and seven others lightly damaged.

Extensive splinter damage was caused to compartments below deck. Two large splinters penetrated to the 285 radar room and killed or wounded the crew. Another struck the upper deck in a wardroom and was deflected upwards and out of the side plating. Splinter damage was especially severe to electric cables, and the firemain riser to the boat deck was severed.

A few small fires broke out, but were quickly extinguished. Fortunately, the gasoline in the boats had been drained, or a severe fire could have broken out on this deck.

An 8-inch shell that failed to explode hit a 45-foot motor launch on the boat deck (see figure 5-5), passed through the deck (about 15 feet to starboard) and several partition bulkheads in the spaces below, and finally penetrated the 1.47-inch armor plate forming the casemate of the number 3 port 5.25-inch mount. The angle of impact was approximately 22 degrees to the normal of the plate. The shell perforated the armor, causing a hole about 8 by 9 inches. The back of the armor plate was split and torn in petal form and showed severe local lamination.

In passing through the 1.47-inch armor, the shell was deflected upward and forwards and struck the 0.75-inch ring bulkhead at a point some 20 inches below the



Hit No.4 - (8") Path of shell which penetrated to the port 5.25" shell handling room. Shell landed in 5.25 shell handling room, failing to detonate.

Figure 5-5. Shell Hit on Boat Deck and in 5.25-Inch Handling Room

shelter deck and 3.5 feet forward of its penetration of the armor. The shell did not penetrate the ring bulkhead but opened a hole some 20 inches long and 20 inches deep. The metal detached was folded back like a tongue. The roller-path support inside the ring bulkhead was distorted, but the gun mounting was not damaged.

The shell ricocheted off the ring bulkhead in an upward and aft direction and struck the lower flange of the channel bar deck beam at a point some 30 feet forward of the opening in the 1.47-inch armor cited above. Damage to the beam was slight, indicating that a good portion of the shell's velocity was spent. The shell then struck the port side of the 1.47-inch noncemented armor some four to five feet forward of the deck beam damage. At this point the shell fell to the deck and did not explode. It was thrown overboard.

Damage to the equipment within the casemate was small, and structural damage was minor within the position. Considerable structural damage in the form of torn plating and beams was caused along the shell's trajectory within the ship prior to its entry into the casemate. Electric leads to the revolving structure of the port number 3 mount were severed.

One 15-inch shell traveled some 80 feet underwater before striking the ship about 28 feet below the waterline. The bearing at entry was estimated to be between 40 to 50 degrees to the ship's centerline. The shell hit the ship outside the starboard diesel generator room and 12 inches above the bilge keel. It traveled some 12 feet within the ship before coming to rest, without exploding, against the torpedo bulkhead in the inner void of the side protection system, as shown in figures 5-6 and 5-7.

The entry hole was irregular in shape, about 18 inches long and 18 inches high and extended from 7 inches above the bilge keel. The plating at the upper edge of the hole was turned inboard and that at the lower edge was bent outboard.

Once inside the ship it perforated two bulkheads of 0.375 inches thickness, with their frames and brackets, and traveled a distance of 12 feet to the protective bulkhead in comparatively stable flight. The nose of the shell gouged out about 0.25 inches of

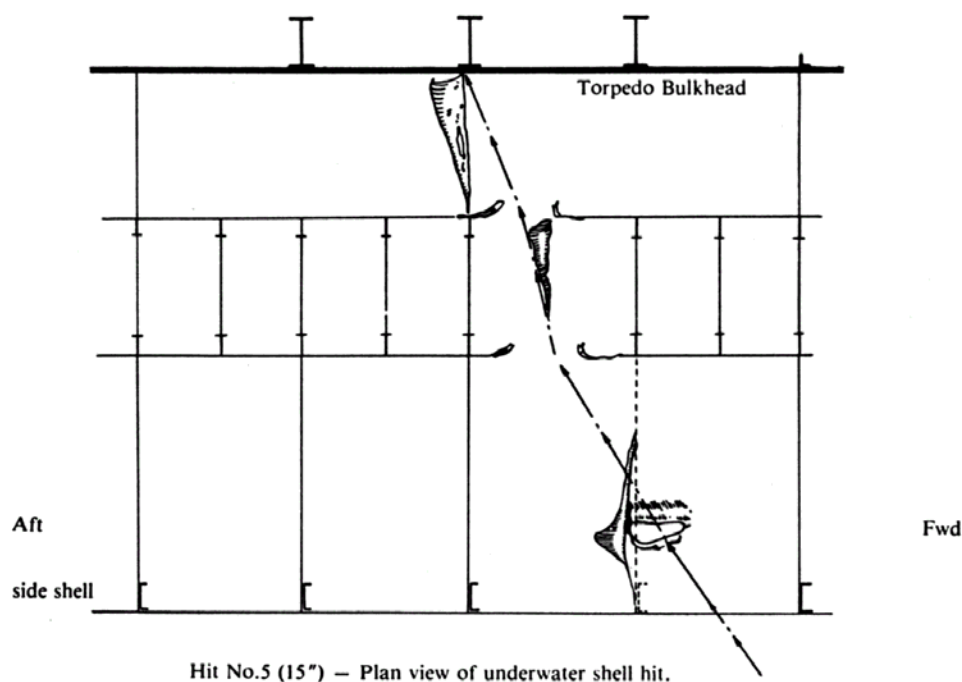


Figure 5-6. 380-mm Underwater Shell Hit

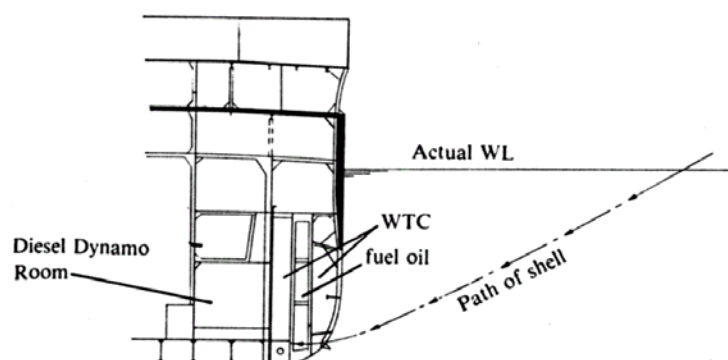
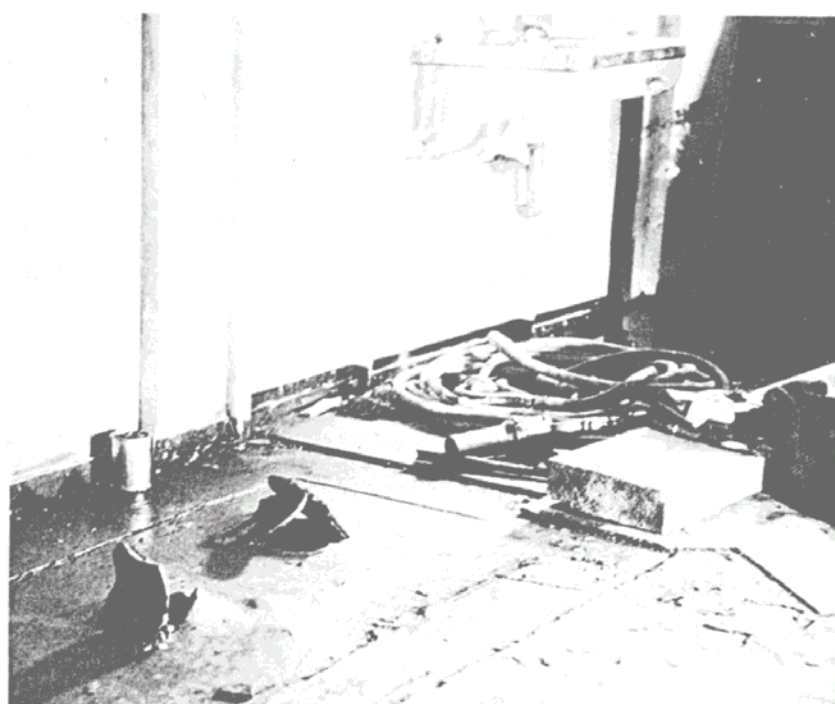
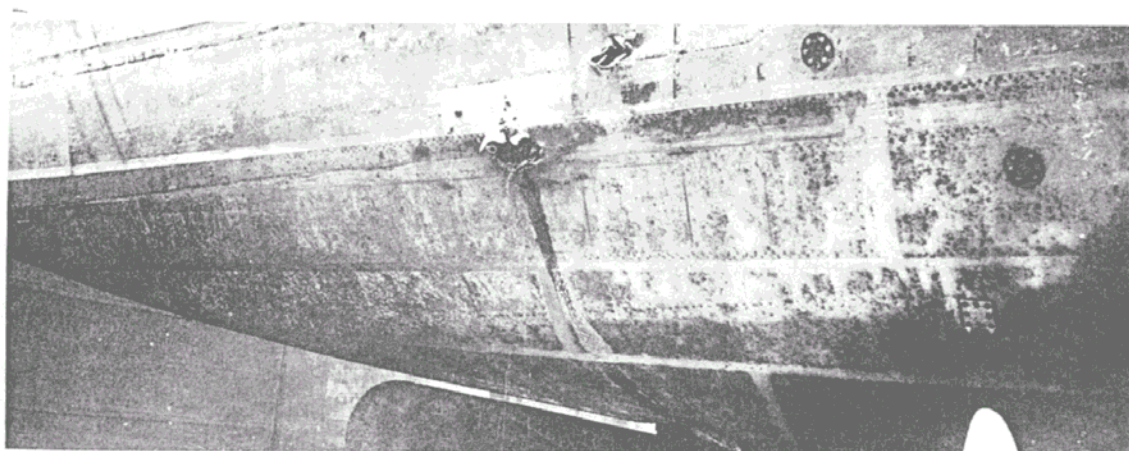


Figure 5-7. Section View of 380-mm Underwater Shell Hit—Stern



An 8-inch shell caused some minor damage to the interior of the Prince of Wales abaft the armored citadel. Fragmentation damage is shown here to the middle deck, above the point of burst (approximately frame 276). (Royal Navy, HMS Excellent)



This is damage from an 8-inch shell that struck the ship just forward of the rudder post. The shell broke up as it penetrated the side—the upper hole is the point of entry; the lower hole is from the splinters' exit from the ship. (Royal Navy, HMS Excellent)

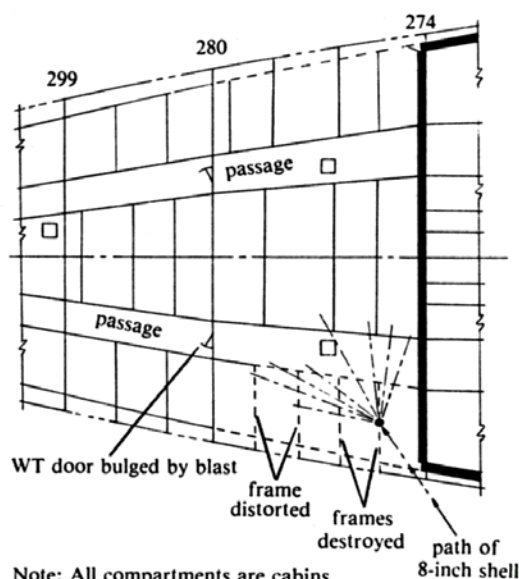
the torpedo bulkhead over an area some 4 inches long by 2.5 inches wide. The shell fell away from the torpedo bulkhead and did not explode. It was later found in Rosyth in the inner air space lying on the outer bottom plating with its nose pointing forward. The shell was in good condition with its fuze in place, but without its ballistic cap.

The outer and inner voids and the intervening fuel-oil tank were flooded. Rivets connecting bracket frames to the torpedo bulkhead were sheared, permitting water to leak into the diesel generator room. Some diesel oil seeped through sheared riveted connections. The flooding caused a slight reduction in speed, and the loss of fuel and diesel oil caused a reduction in the endurance of the *Prince of Wales*.

Two 8-inch projectiles struck the shell plating abaft the after armored bulkhead and exploded within the ship. The first shell opened a hole 18 inches by 17.5 inches in the 0.75-inch side shell (see figures 5-8 and 5-9). It traveled some 11 feet within the ship before exploding with a low-order detonation. Blast and splinter damage were not extensive; partition bulkheads for staterooms in the area were destroyed. A watertight door on the first main transverse bulkhead abaft the armored bulkhead on the starboard side of the lower deck was blown open and distorted. There was flooding in the area of the hit, as the shell had a partial underwater trajectory. The degaussing coils were cut by splinters. Splinter damage was localized to the area of penetration. There were no splinter holes in the lower armor deck, the ship's side, or the after armored bulkhead. There were splinter holes in the light bulkheads bounding staterooms in the area of the hit and in the deck over the lower armor deck.

The lower deck experienced some flooding from the after armored bulkhead to the transverse bulkhead immediately aft, as it was open to the sea on the starboard side. The starboard shaft passage below the lower armor deck flooded through the air escape pipes which had been damaged by shell splinters. The middle deck flooded through splinter holes over two compartments. The nature of this flooding was confined mainly to the starboard side.

The second 8-inch shell, with a slight underwater trajectory, struck just forward of the rudder stock (see figures 5-10 and 5-11). It struck the ship about five feet below the waterline and six inches above the lower deck. It exploded while passing through the shell plating and in doing so ripped a 21-by 8-inch hole in the plating. The nose of the projectile and part of the body were blown into the ship and struck the sloping portion of the 3.43-inch armor over the steering-gear room. The nose portion was deflected by



Note: All compartments are cabins.

Figure 5-8. Plan View of 203-mm Shell Hit—Stern

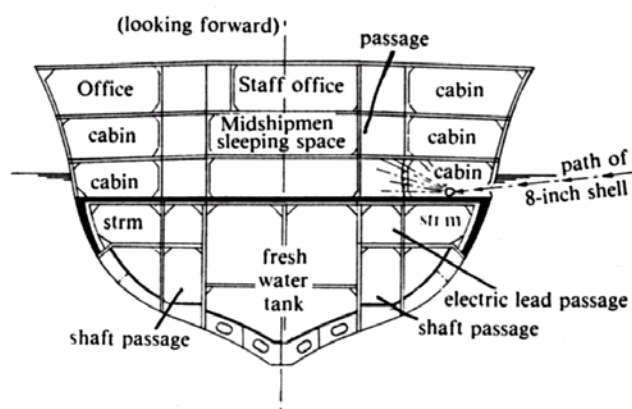


Figure 5-9. Section View of 203-mm Shell Hit—Stern

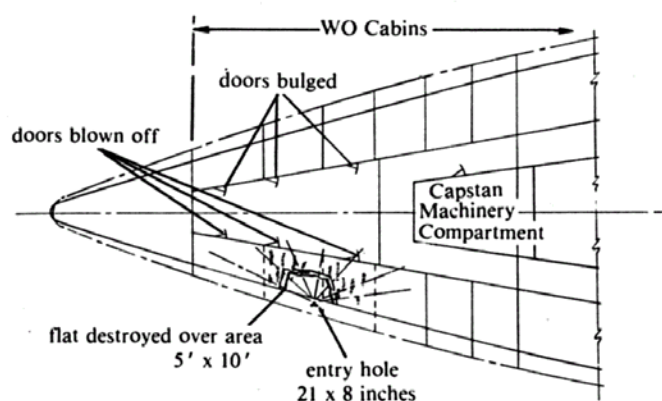


Figure 5-10. Plan View of 203-mm Shell Hit in way of Steering-Gear Room

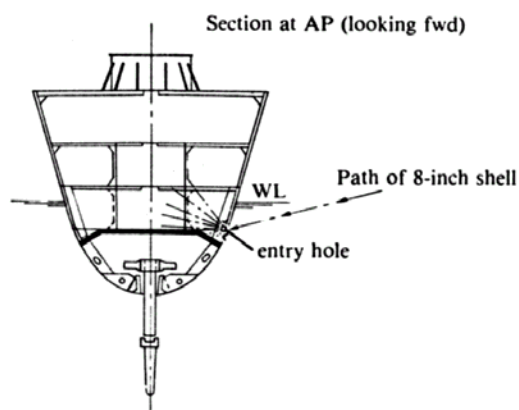


Figure 5-11. Section View of 203-mm Shell Hit in way of Steering-Gear Room

the sloping armor and subsequently passed out of the ship some six feet abaft its point of entry. The hole was of irregular shape, 32 inches long and 13 inches wide, with its edges turned outboard. Its forward end was 18 inches abaft frame 312 and its lower edge 5 inches below the upper surface of the sloping armor. A number of small splinter holes were above and abaft this large hole.

Damage within the ship was not extensive, but the lower armor deck plating between frames 310 and 314 and inboard to the knuckle of the armor were blown away. Forward of frame 310 for a distance of some 20 feet, the lower armor deck was pushed up and distorted. Partition bulkheads of the starboard staterooms in the area of the hit were destroyed. The deck was perforated by a large splinter at frame 317. The sloping armor over the steering-gear room was pushed down (maximum distortion 0.375 inches).

Outside the ship, the explosive force of the shell's detonation created a pressure pulse in the water and caused local dishing of the side frames within ten feet of the explosion. Since the shell hole was some five feet below the waterline, there was local flooding in the area. The staterooms bounding the area of the shell hit were open to the sea. The baggage storeroom on the lower deck from frame 317 to the stern was flooded, presumably through a distorted watertight door. The staterooms above the area of the shell hit also experienced some flooding (12 inches above the deck), through splinter holes in the deck.

The ship experienced a slight starboard list which was quickly removed by flooding port voids.

The new and untried condition of the ship began to show up as the main battery started firing three-gun salvos instead of the normal five-gun salvos. First, salvos were missed due to minor mechanical failures, then there were breakdowns in the elevating and training gears, except for "B" turret, which gave no trouble during the action. The main-battery fire was reduced as much as 25 percent due to mechanical problems, as out of seventy-four rounds ordered fired, only fifty-five were possible. Vickers Armstrongs technicians performed invaluable services in correcting problems that arose.

Throughout the action the conditions in the shell-handling room of the forward quadruple turret were very bad; water was pouring down from the upper part of the mounting. There was only one drain at the time and it became clogged, with the result that water accumulated and washed from side to side as the ship rolled. The streams above and the flood below drenched the machinery. It was also of considerable discomfort to the gun crew. To complicate matters, "A" turret jammed.

At 0603, with the range down to 14,500 yards, Captain Leach decided to open range, as he was fighting a superior foe at an extreme disadvantage. At 0605 he decided to disengage and in doing so laid down a heavy smokescreen. He was faced with an extremely difficult decision; the crew was not at battle efficiency, the ship had been seriously damaged, the main armament had a number of known defects that were hampering 14-inch fire, splinter hits in three of the four 5.25-inch directors hampered fire from the 5.25-inch guns (the 5.25-inch battery opened fire at a range of 18,600 yards, but fired only three salvos), and his only help, the *Hood*, had blown up. He had to decide whether to risk the loss of a new ship in a death or glory struggle against heavy odds, or withdraw before the *Prince of Wales* was too damaged to fight again.

The *Prince of Wales* fired eighteen main-battery salvos in fourteen minutes, with two hits and one near miss. At 0613, as she was turning away under her own smoke-screen, a shell slid out of the port shell room of "Y" turret and fouled the revolving shell ring while the latter was locked to the trunk and the turret was training. The hinge tray was severely buckled, forcing the revolving shell ring out of action. The jam was cleared at 0825. This temporarily left only two 14-inch guns operational, but nine of the ten were again ready for use within five hours.

The *Prince of Wales* radioed the *Norfolk* that the *Hood* had sunk, and then joined up at a point some 15 to 17 miles astern of the *Bismarck*. Rear Admiral Wake-Walker aboard the *Norfolk* was now the senior officer, and Captain Leach informed him of his ship's condition—bridge destroyed, turrets "A" and "Y" out of action, damaged 5.25-inch directors, and best speed 27 knots because of 600 tons of flooding water. Four hours later, he reported that the main and secondary batteries were ready for action.

Pursuit of the Bismarck. The British ships steamed at high speed throughout the day to keep in contact with the German ships until, at 1816, with the *Suffolk* some 26,000 yards astern and to port of the *Bismarck*, the range suddenly began to decrease as the *Bismarck* closed in a feint to cover the detachment of the *Prinz Eugen*. At 22,000 yards the *Suffolk* turned to port to open the range, but the *Bismarck* was able to close to 20,000 yards and fired nine full broadsides, all of which missed by at least 1,000 yards. The *Prince of Wales* then opened fire on the *Bismarck* at a range of 30,300 yards. Twelve salvos were fired, but all missed because of the extreme range. Visibility was also poor due to rain squalls. A total of forty-one rounds were fired out of a possible forty-eight—a 14 percent loss of firepower. Observers on the *Norfolk* saw one salvo straddle the *Bismarck*.

At 0020 on 25 May, torpedo planes from the carrier *Victorious* attacked the *Bismarck* and made one hit amidships that had no effect on her speed. The *Prince of Wales* regained contact around 0100 and at 0131 opened fire at a range of 20,000 yards. Fire was checked after two salvos due to poor visibility. The shell ring in "A" turret jammed, leaving only six guns operational. British observers believed that a hit was made on the *Bismarck*, as in addition to her gun flashes, a different type of explosion was seen at the same time the shells from the *Prince of Wales* were due to fall. Shell splashes could not be discerned due to poor visibility*. A few hours later the British lost all contact, and after a futile search of twelve hours, the *Prince of Wales* headed for Iceland, where she arrived with only 6 percent of her fuel remaining.

Repairs and modifications. After refueling and landing the dead and wounded, the ship sailed to Rosyth for repairs to topside structure and further work on the turret machinery and 14-inch guns. On passage to Rosyth, two more hinge trays in "Y"

* There is some disagreement concerning this reported shell hit by British observers. German survivors indicate that no hits were made at this time.

shell-handling room were buckled by fouling the revolving shell ring. The unexploded 15-inch shell was found in the inner air space of the side protection system outside the diesel generator room. In order to remove the shell from the ship and the dockyard as soon as possible, extra holes were cut in the bottom plating. Six weeks were required to repair and return the ship to service.

Captain Leach noted in reports on the action that better communications were necessary for proper damage control in emergencies, better fittings were required for portable pumps, trunk accesses should be installed to all compartments outside the armored citadel, and ventilation to all four auxiliary machinery rooms needed improvements. The latter was a serious problem, with temperatures reaching 120°F. Other comments were:

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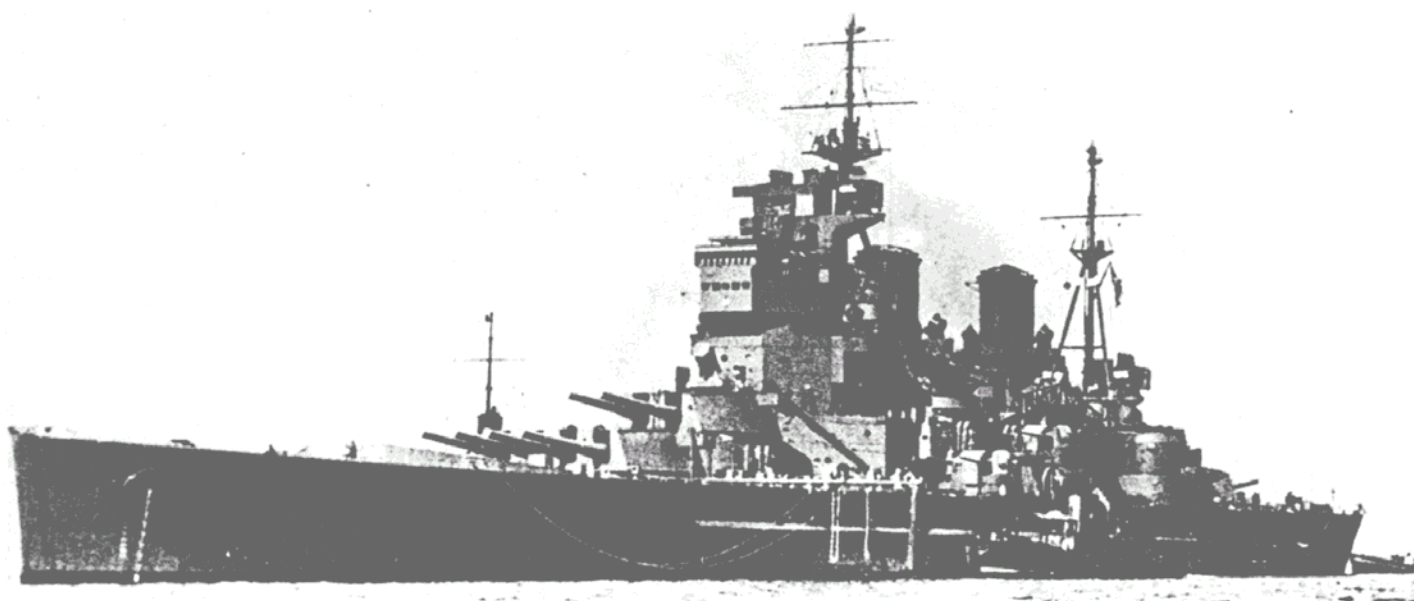
- If radar rooms were to be retained above the armor deck, they should be splinter proof.
- Boiler room air intakes, when near a funnel, were liable to gas the boiler room personnel if the funnel was damaged.
- High-angle directors were vulnerable to the lightest of splinters.
- Wooden boats were a potential fire hazard.
- Protection should be given to searchlight control cables and cables to the after emergency conning station.
- There was inadequate ventilation to diesel generator rooms, main switchboards, and ring main compartments.
- Fan casings and light fittings were unable to withstand shock damage.
- Because of high-speed steaming, seawater poured into "A" turret through its gun ports and joints of the gun house. Drainage of water was difficult, and loose water drenched machinery and caused extreme discomfort to the crew.
- The main machinery steamed at overload powers of 128,000 to 134,000 shaft horsepower with no difficulties. However, the fuel oil pumps would not feed well when drawing oil from distant tanks.

Atlantic Charter meeting. During August 1941, the ship carried Prime Minister Winston Churchill and a large staff from Scapa Flow to Newfoundland for the Atlantic Charter meeting with President Roosevelt. On 10 August 1941, President Roosevelt and a large staff came aboard the *Prince of Wales* for a Divine Service on the quarter-deck. In a few months, some of those present were to go down with the ship.

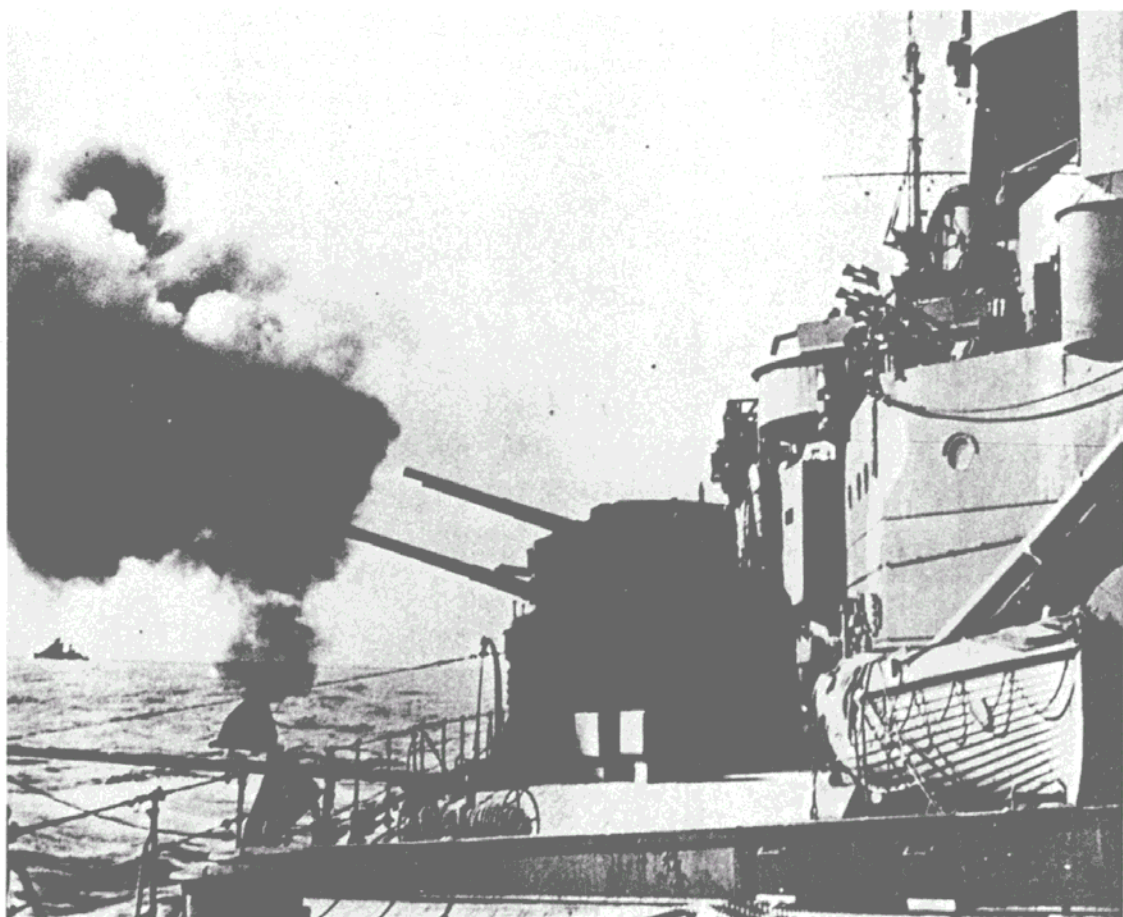
Mediterranean duty. After returning to Scapa Flow, she was assigned to the Mediterranean for convoy duty in company with the *Nelson*. On 27 September off Malta, the *Prince of Wales* shot down several attacking Italian aircraft with her 5.25-inch guns.

Assignment to Singapore. In October 1941, Churchill directed that a battleship and an aircraft carrier be sent to join the *Repulse* at Singapore. The Admiralty was reluctant to send a *King George V*-class ship, fearing German attacks on the Atlantic convoys. Even the fleet surgeon objected, pronouncing the ships unfit for tropical duty without changes to their ventilation systems. But Churchill insisted, and on 25 October the *Prince of Wales*, along with the destroyers *Electra* and *Express*, departed for Singapore to become the flagship of the Far East Fleet under Admiral Sir Thomas Phillips. The new carrier *Indomitable*, scheduled to join the force at Capetown, ran aground at Kingston, Jamaica, and had to be repaired. No replacement could be spared.

The *Prince of Wales* joined the *Repulse* in Ceylon; both ships arrived in Singapore



This is the Prince of Wales in August 1941 at Argentia, Newfoundland, during the Atlantic Charter meeting of President Roosevelt and Prime Minister Winston Churchill.



This is a starboard view of the forward 5.25-inch guns of the Prince of Wales in action, sometime during 1941.

on 2 December 1941. They had drilled in air-defense measures, but against much slower types of aircraft than those with which Japan entered the war.

Sortie from Singapore. At 1230 on 8 December (the day of the Pearl Harbor attack on the other side of the International Date Line), the British met aboard the *Prince of Wales* to formulate a plan of action against the Japanese landing forces at Singora and Kota Bharu in Malaya, which were believed to be covered by a *Kongo*-class battle-cruiser,* five cruisers, and twenty destroyers. Admiral Phillips had intended to use land-based fighter cover for a surprise attack at dawn on 10 December, and Force Z, consisting of the *Prince of Wales*, *Repulse*, and destroyers *Electra*, *Express*, *Tenedos*, and *Vampire*, got under way at 1735 on 8 December. This force steamed east, then north, at 17.5 knots under the cover of darkness. At 2253 Admiral Phillips was informed that there would be no air cover for his operations. The movement of the British force was soon discovered by Japanese aircraft and submarines, so the British commander-in-chief had lost two vital elements of his plan—air cover and surprise. The Japanese transports off Malaya would be withdrawn, and Japanese warships would be sent south to intercept the British.

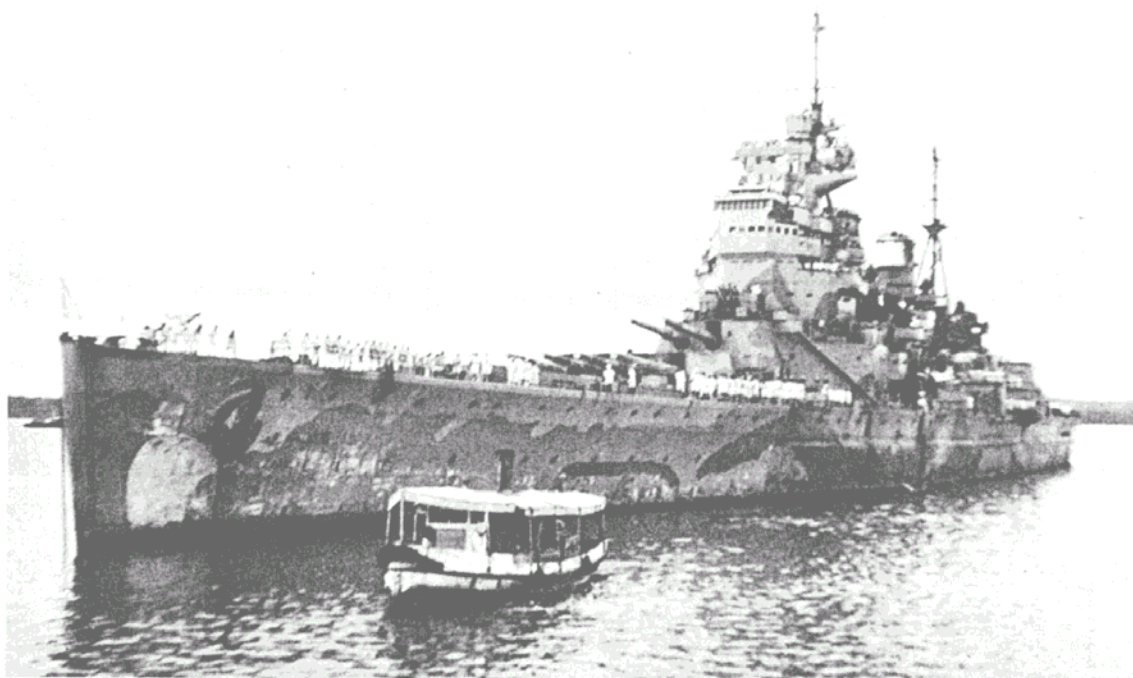
During the next twenty-four hours there were several sightings on both sides. At 1345 the Japanese submarine *I-65*, at extreme range, spotted the two capital ships. The submarine maintained contact, then lost it; however, it did send a sighting report. In the meantime, Force Z steamed northward under low cloud cover and intermittent rain squalls. Around 1700 the weather suddenly cleared. Shortly thereafter three enemy reconnaissance planes† spotted and tracked the British force until 1830. Force Z was unable to evade them with course alterations and prepared for an air attack. Captain Tennant of the *Repulse* signaled Admiral Phillips that in the event of an air attack, he would prefer a speed of 24-25 knots, since at speeds of 27 knots and above, vibrations would impair the effectiveness of his 4-inch dual-purpose guns.

The Japanese were taken by surprise when the signals of *I-65* indicated the presence of British warships so far north. Japanese transports off Malaya were ordered to stop unloading troops and scatter to the north. A force of seven cruisers and five destroyers was sent south to search for the British ships. Vice-Admiral Kondo had two battleships, the *Kongo* and *Haruna*, under his command, but they were some twelve hours' steaming from the reported position of Force Z. A further force of six cruisers and additional destroyers would be able to join the search the next morning. Once the sighting report was received in Saigon, the 22nd Air Flotilla launched a strike force of some fifty-three aircraft on 9 December. They failed to sight the British ships, but found Admiral Ozawa's cruiser and destroyer force instead. As it was night at the time, a flare was dropped to illuminate the ships for an attack. Only frantic signaling between Saigon and Admiral Ozawa in the *Chokai* prevented these Japanese planes from torpedoing their own ships. The aircraft were recalled.

Admiral Phillips had to make some important decisions regarding the composition of his force during the evening hours of 9 December. The *Tenedos*, low on fuel, had to be detached at 1835 for return to Singapore. With his other destroyers also low on fuel, he was debating whether to make a dash to Kota Bharu with the *Prince of Wales* and *Repulse* to intercept the Japanese transports, using darkness to cloak his movements. Around 2000 Admiral Phillips reluctantly decided to cancel the mission, since surprise had been lost and Japanese aircraft had probably sent reports on his position. While steaming south towards Singapore, he was informed at 0052 on 10 December that the Japanese were landing at Kuantan. Shortly thereafter, he ordered a course

* There were actually two—*Kongo* and *Haruna*.

† From the cruisers *Kinu*, *Suzuya*, and *Kumano*.



The Prince of Wales at anchor in Singapore early in December 1941. The camouflage scheme shown was applied in Rosyth after the completion of battle damage repairs in July 1941. She was the first Royal Navy battleship to use a multicolor disruptive pattern. (Imperial War Museum)



The Prince of Wales is getting under way from Singapore, 8 December 1941. (Imperial War Museum)

change and a speed of 25 knots for all ships. At 0211, *I-58* made an unobserved and unsuccessful torpedo attack (target—*Repulse*), and reported their position and heading. This was a vital piece of information to Japanese forces, for it indicated that the British were headed away from the landings in Malaya and that interception by surface forces would probably be out of the question.

All British ships were at full battle readiness when dawn broke around 0500. At 0514 a tug (or steamer) towing what seemed to be three barges was sighted heading south. At 0630 lookouts on the *Repulse* spotted an aircraft low on the horizon. Once the aircraft had disappeared, the *Prince of Wales* launched a Walrus aircraft for reconnaissance of Kuantan. The pilot reported no ships or activity in the area.

At 0800 on 10 December, Force Z arrived off Kuantan, but found no invasion fleet. The *Express* reconnoitered the harbor and reported "complete peace." Unable to locate the Japanese, Admiral Phillips ordered his force eastwards to search for the tug and barges seen shortly after dawn. Speed was reduced to 20 knots to conserve fuel in the destroyers. A Walrus seaplane was flown off from the *Repulse* to provide an antisubmarine patrol.

At 0625 the first units of some seventy-nine attack aircraft took off from Saigon. Reconnaissance aircraft had left earlier. The Japanese attack force was equipped with bombs or torpedoes and if necessary would fly as far south as Singapore to attack Force Z.

At dawn the *Tenedos*, well south of Force Z, sighted a Japanese plane. At 0950 she reported a large formation of aircraft and twenty minutes later reported that she was being bombed. Upon receipt of the latter message, Admiral Phillips ordered a course change to the southeast. The sea was calm, ceiling 10,000 feet, air temperature 78-80°F, and visibility some five miles. At 1040 the fleet sighted a Japanese plane which was directing aircraft of the 22nd Air Flotilla to an attack; action stations were sounded and speed was increased to 25 knots.

Force Z under air attack. At 1100 radar detected a large formation of aircraft; within minutes they were sighted. The Japanese at first concentrated on the *Repulse*, as their doctrine was to attack the largest ship first, and from their altitude she appeared to be larger. About 1110, eight twin-engine bombers made a close-formation bombing attack. The *Repulse* took one 550-pound bomb hit nearly amidships and experienced seven near misses. As the enemy planes approached the port bow of the *Prince of Wales*, she opened fire with her 5.25-inch guns. While this did not break up the attack, five planes were damaged, two of which had to return immediately to base. Unfortunately for these gunners, Admiral Phillips ordered a formation change which prevented sustained fire.

At 1138 twenty-five twin-engined bombers approached the *Prince of Wales* on the starboard bow; nine were at a height of 10,000 feet, while the remainder were at an altitude of 5,000-7,000 feet descending rapidly in single-line formation. The higher flying squadron continued north, as it had expended its bombs on the *Tenedos*, but the lower formations were equipped with a Type 91 torpedo, armed with TNT and Hexyl charges of 330 pounds. The torpedoes were set for a depth of 10 to 15 feet and were capable of a 40-knot speed for 2,200 yards. The attack began at 1142. Despite intense antiaircraft fire, the gunners had difficulty in coping with the planes, which were flying at lower altitudes and at higher speeds than any targets they had ever fired on in drills. The Japanese commenced their attack runs at 2,500 yards and released torpedoes at an altitude of 100 feet, some 1,000-2,000 yards off the port side. The first group of nine planes launched its torpedoes and overflew the *Prince of Wales*, machine-gunning the decks of the battleship. Only one plane was shot down. The second group of seven attacked the *Repulse* minutes later.

Torpedo hits—first attack. Too late, the *Prince of Wales* began a port turn to comb the torpedo tracks to protect her rudders and propellers. At 1144 two or three torpedoes detonated against the port side aft (see figures 5-12 and 5-13), one abreast of "Y" turret and one (or possibly two) near the after group of 5.25-inch mounts.

These torpedoes caused severe structural damage, with the first detonation being exceptionally heavy.* The most extensive structural damage and flooding occurred from "B" engine room to the after 5.25-inch magazines. The port inner and outer voids of the side protection system from frames 184 to 253 flooded immediately. This, with almost immediate flooding of the port shaft alley, quickly produced a large list to port.

The first torpedo, which hit near "Y" turret, exploded on or near the trailing edge of the port propeller strut near frame 289. The torpedo struck an area of the underwater hull where there was a pronounced concave shape inboard. The full force of this torpedo's explosion was vented into the ship. The strut arm failed, and the port outboard propeller was probably loosened and in time ran off the shaft. More important, however, was the fact that the shaft was distorted and the propeller kept turning without the support of the shaft strut. In a short time the distortion in the shafting opened all the watertight bulkhead stuffing glands, including that on the after bulkhead of "B" engine room. Lt. D. B. H. Wildish, in command of the space, realized that the shaft had experienced some serious damage, and without specific orders he had the shaft stopped. He recalled twenty-five years later that:

There was a terrific thump, and the ship whipped around like a springboard for a few seconds. My turbine started to vibrate at once, and I ordered it to be shut down . . . we checked the unit for the usual important details . . . and we . . . gradually brought it up to 150 rpm, despite some vibration . . . Very soon after, water began to pour out of the shaft bulkhead gland, and I tried to keep this flood water down by using the engine room's pumping facilities. It was to no avail. Then we tried using the main circulating bilge suction, which also proved to be unsuccessful. We had to evacuate . . . I took the necessary action to prepare the turbine for steaming under flooding conditions.† . . . The shaft was turning when we left . . . we had just enough time to shore the hatch down for added security before water began to seep around the edges of the hatch coaming at the joint.

Within eighteen minutes "B" engine room had flooded completely.

* Testimony of surviving Japanese aviators and Captain Tennant of the *Repulse*. The latter was challenged by Boards of Inquiry investigating the action.

† This involved measures to prevent seawater from entering the lube oil and feedwater systems.

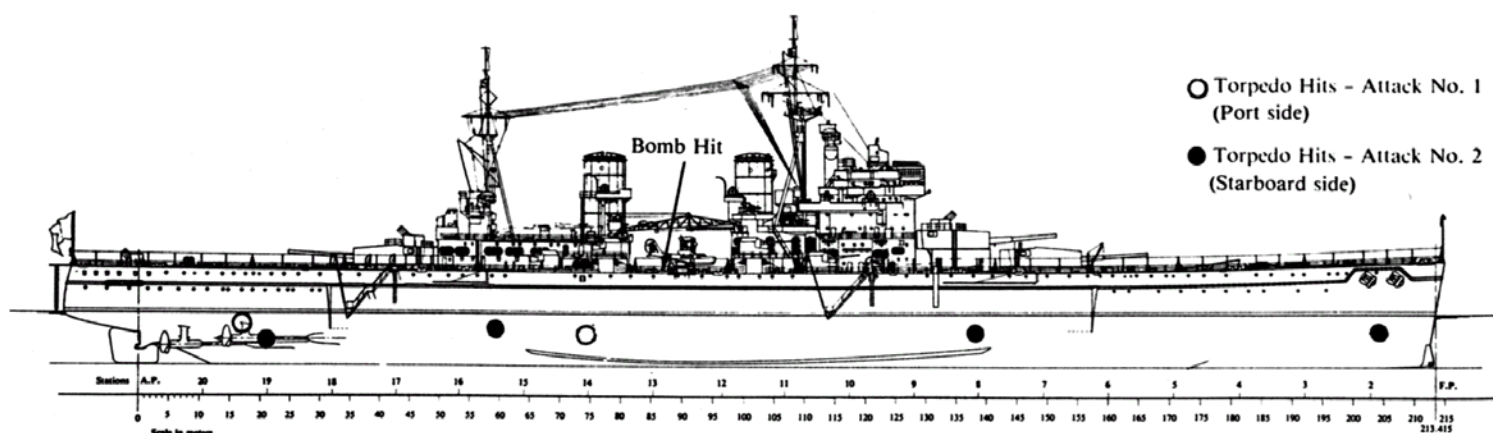
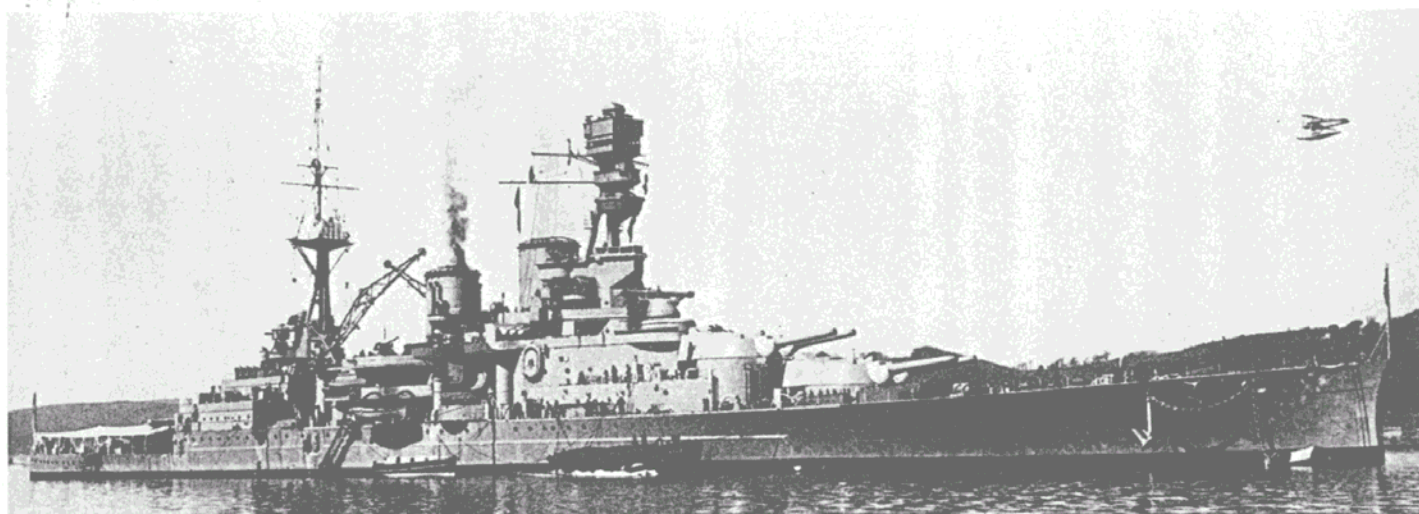
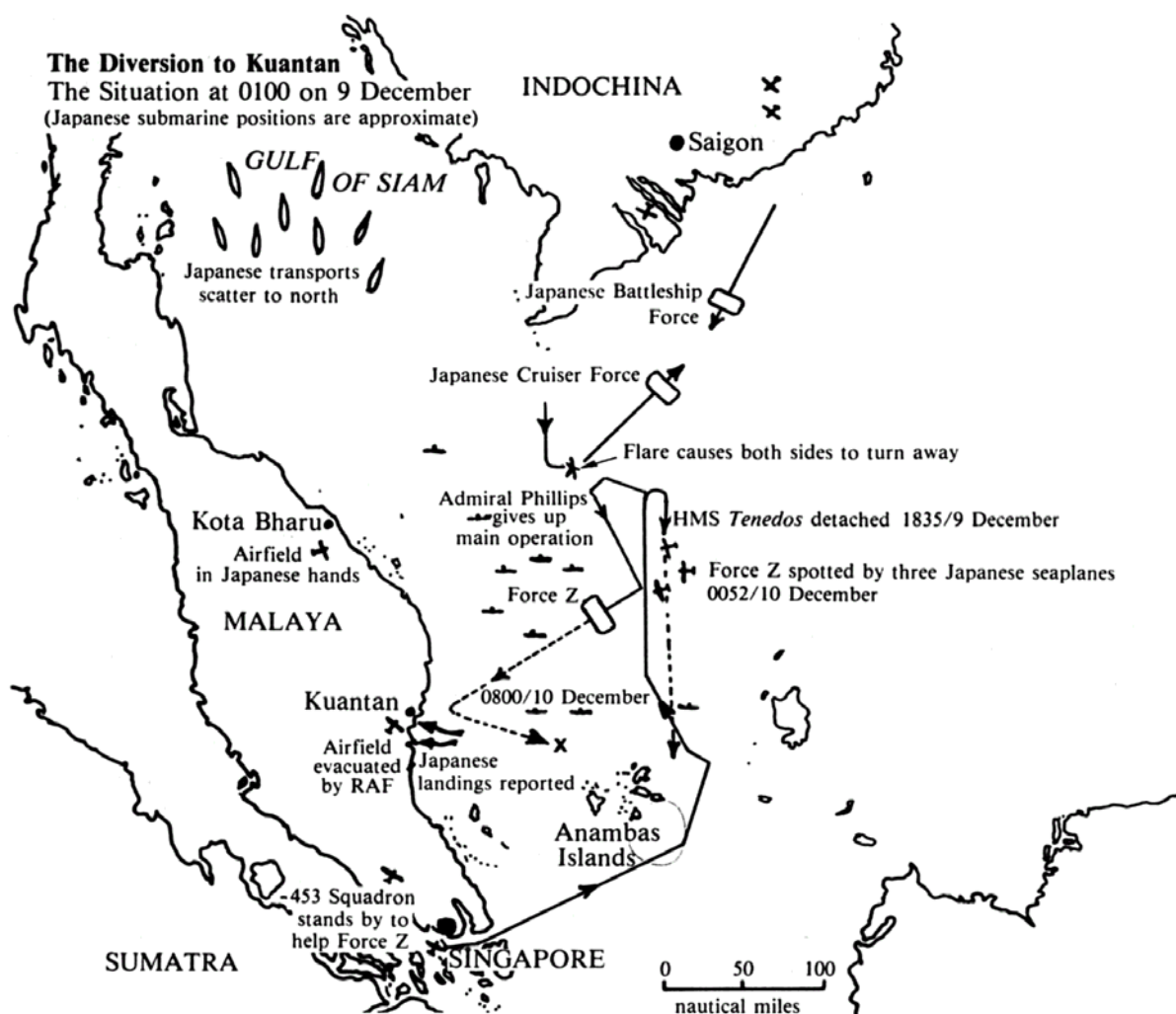


Figure 5-12. Location of Torpedo and Bomb Hits—Prince of Wales



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The Repulse, shown here in 1939, was assigned to the East India Station and sailed for Ceylon in October 1941. The Repulse, Illustrious, and Prince of Wales were to form the nucleus of Force Z, but the Illustrious sustained grounding damage and could not join the battleship-battlecruiser force under the command of Admiral Sir Thomas Phillips. (Henri Le Masson)



The track of Force Z in their operation to intercept the Japanese invasion fleet. The Prince of Wales sank at 3°33.6'N, 104°23.7'E, marked with an X, at 1323 on 10 December 1941.

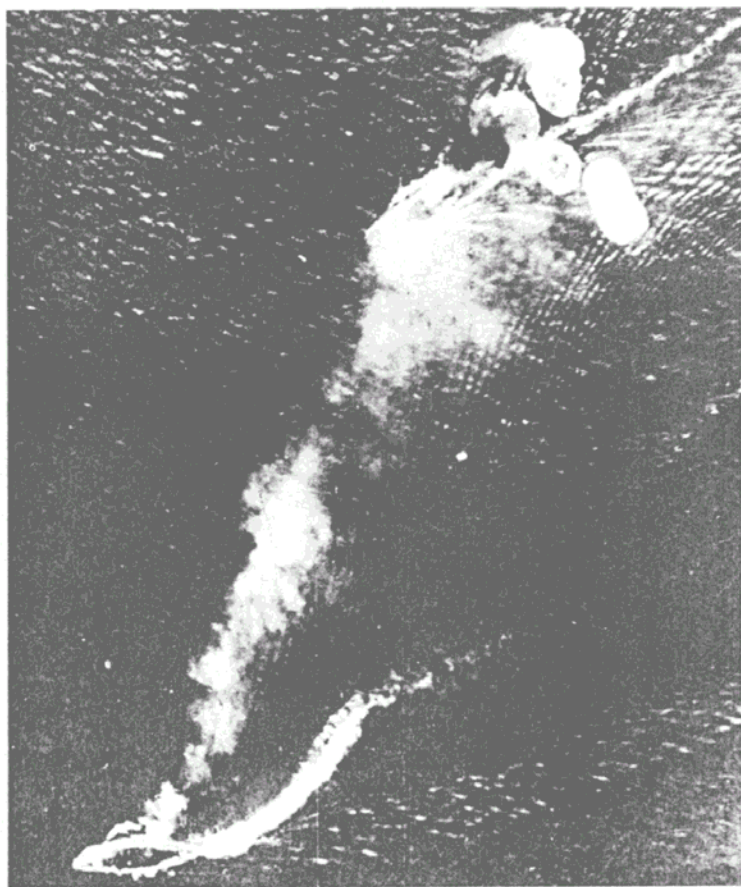
Excessive vibration and warping of the shaft had probably loosened rivets in the line bearing and main-thrust block foundations, distorting the shaft, which finally caused an annular ring to develop in the stern gland. The shaft was observed to be rotating out of center. This was probably aggravated by the bent shaft ripping into the stern structure, since many survivors from these areas heard banging and thumping from positions as far away as frame 200. A large piece of the wrecked strut ripped a hole in the shell plating, which caused some flooding in the inboard shaft alley. In 1966, Royal Navy divers examined the wreckage and found the bare shaft had pulled away from the ship, snapping the strut in the process. A few feet forward of the A-bracket stub, there was a large hole about 12 feet in diameter with the shell plating jaggedly bent inwards.

The other torpedo (or torpedoes) exploded just abaft a main transverse watertight bulkhead at frame 206. From visible evidence and the subsequent damage, it seems plausible that two torpedoes detonated near this bulkhead in close proximity, virtually simultaneously. Such a sympathetic detonation is possible within a distance of approximately 160 feet, and the second explosion would be almost indistinguishable from the first, except that a greater amount of water would be thrown up by the two detonations. In fact, the magnitude of damage and flooding would be better described by two torpedo hits rather than one. The torpedo hit (or hits) produced severe structural damage between the "Y" turbogenerator (action-machinery) room and the port diesel generator room.

A survivor from the port diesel generator room claimed that the transverse bulkhead (frame 206) at the after end of this space "caved in." Such damage is very significant, since it confirms a torpedo hit close to the bulkhead. The claim that the bulkhead collapsed into the space indicates that the torpedo struck abaft the bulkhead. The closer the torpedo struck to the main transverse bulkhead, the greater the amount of deflection carried into it by the deformation of the very strong torpedo (longitudinal) bulkhead. The deformation of the main transverse bulkhead was carried well inboard, despite precautions taken by the structural designers and the lessons learned about bulkhead structural details during the Job-74 tests. It caused some damage to a flat in way of a reserve feedwater tank in "Y" boiler room. The designers had given special consideration to this flat's design, but the deflection from the longitudinal torpedo bulkhead was great enough to destroy the watertight integrity of the feed tank.

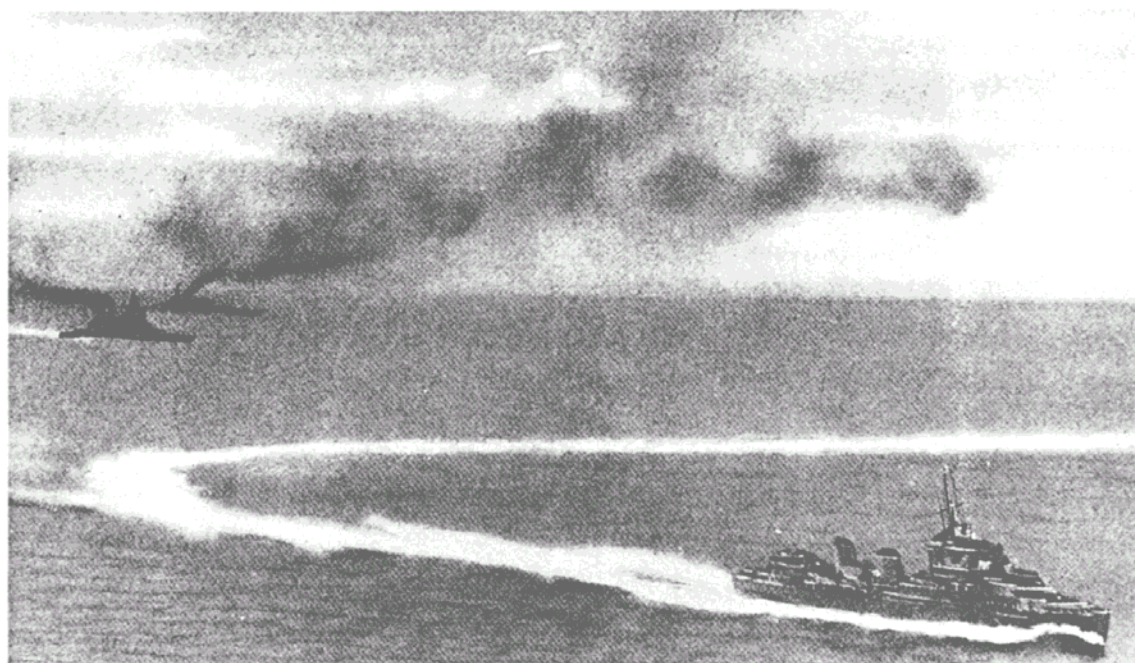
A survivor from the "Y" action-machinery room reported damage to the turbogenerator, while another claimed that the outboard main propulsion shaft which passed through this space broke. This was probably incorrect; what he may have seen was the line bearing being pulled off its foundation by a wobbling shaft. The "Y" action-machinery room and number 12 breaker room, immediately above, flooded rapidly. There are no details available of structural damage to these compartments, but it is possible that the flooding could have been caused by damage to, or insufficient closure of, a watertight door into the escape trunk from the compartment below. A considerable amount of steam collected at the forward end of the action-machinery space, making escape from this compartment hazardous. A survivor from breaker room 12 claimed to have seen two badly burned men going up the escape trunk. The "Y" action machinery room was a hot space with superheated steam coming to the turbogenerator from "Y" boiler room. The steam pipe was insulated, but the exhaust from the generator was not. Another steam pipe went to the hydraulic pump. It is quite probable that one or all of these pipes ruptured when flooding water made contact, releasing superheated steam, further complicating damage control.

The inner and outer voids of the side protection system flooded immediately, as shown in Figure 5-13, and water quickly inundated the port diesel room and the "Y"



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Force Z under attack by Japanese high-level bombers on 10 December 1941. The Repulse, upper right, has just been struck by a bomb. Note the near misses. The Prince of Wales, lower left, is turning to starboard in an effort to evade enemy bombs. (Imperial War Museum)



A dramatic photograph, despite the obvious retouching, shows the Prince of Wales (far left) and Repulse after the first torpedo attack, during which the Prince of Wales sustained heavy torpedo damage. Shortly after this picture was taken, another torpedo attack succeeded in sinking the Repulse and crippling the Prince of Wales. Note the British destroyer, shown in the foreground, maneuvering to engage Japanese aircraft. (Imperial War Museum)

action machinery room. These two generators were in adjoining compartments, were in the proximity of the torpedo hit, and were located against the torpedo bulkhead. The outer shaft passage (shaft alley) from frames 206-274 also flooded quickly. A pump room (frames 228-274) located over the outer shaft alley flooded, and an open hatch between that pump room and number 14 breaker room permitted water to gush up into this space. The breaker room was used as a passage for ammunition supply for the 5.25-inch shell and cordite to the forward mounting of the port after group of 5.25-inch guns. There were watertight hatches on a watertight door in the longitudinal bulkhead (inboard boundary) that were open because the ship was in action against aircraft. This area was evacuated without the hatches being closed and secured. Water, therefore, poured down the communication chutes into the port 5.25-inch magazines and shell rooms (frames 228-242). Also, there was a watertight hatch in the transverse bulkhead (frame 228) to number 12 breaker room through which the 5.25-inch ammunition and shells are fed, and this too was left open because the ship was in action.

A heavy burden of responsibility for the unnecessary flooding in the region of frames 184-253 on the port side must fall upon the crew assigned to the crypto (cypher) room and the central communications office. They heard air escaping from lower spaces, panicked, evacuated their stations, and told the crews of the port and starboard 5.25-inch magazines to do the same. Men from the central communications office left through a watertight door which was not closed after them. By the time the magazine crews had left their positions, water had reached the hatch on the lower deck outside the central communications office. Eventually, water flooded down into the shell and cordite rooms. A damage-control party closed and shored the hatch over the central communications office complex, but water eventually flooded an annex of the central communications office on the starboard side of a watertight bulkhead by passing through some ventilation ductwork and an unsealed two-inch hole in the bulkhead.

Spaces over the side protection system on the lower deck flooded immediately. It is not clear whether the flooding occurred through ruptured deck structure or man-holes in these spaces, although the latter seems more plausible considering the size of explosive charges in the Japanese torpedo warheads. Because the spaces on the lower deck were living areas for the crew, there were a number of ventilation trunks leading to the main deck with valve closures. The fans were located on the lower deck. Some valves were closed, others were opened, and some trunking structure was damaged so that water seeped up onto the middle deck. The closer the compartment and trunking to the torpedo hit around frame 206, the greater the severity of flooding and damage to the trunk structure.

Substantial flooding occurred in port outer compartments on the middle deck. The shock effect of the torpedo hits probably had shaken loose several clips on the watertight doors to the trunk in the compartment between frames 253-274. This trunk led down to the port outer shaft alley, and as a consequence of the torpedo hits, water from this space came up the trunk and poured onto the middle deck. The doors were later secured by a damage-control party with much difficulty, because the space was half-filled with water. Ventilation valves were closed and then sealed by closing the watertight doors, presumably those on the longitudinal bulkhead.

The situation in the "Y" engine room complex, while not as grave as that in the outer shaft alley and "B" engine room, was serious. The "Y" turbogenerator room flooded rapidly. Shortly after the torpedo struck, the compressor flat above filled with steam, and men evacuated both spaces. Heat made it difficult to secure the watertight door from the trunked access to that machinery room; by the time steam and exhaust valves were secured in the "Y" engine room, the "Y" turbogenerator room had completely flooded.

The port diesel room, forward of the "Y" turbogenerator room, flooded rapidly, and that generator gradually went off the circuit. The chief stoker from the "Y" boiler room heard a heavy thumping noise—possibly a misfiring diesel—from that space. By the time he could reach the diesel room, the access trunk to it had flooded to the level of the lower deck. He secured the hatch to the trunk on the middle deck. An adjoining breaker room did not flood until the men abandoned it. Both spaces shared a common escape trunk, so it seems likely that the watertight door was not fully secured.

The "Y" boiler room, inboard of the diesel generator room, flooded slowly, with some oil floating on top of the water. Because of shock damage to the fuel-oil suction pump, no fuel could be fed to the boilers. With steam pressure at about 200 psi, the main steam stops were shut and the main feed pump was secured. The motor-driven fire and bilge pump and the 1,000-ton-per-hour emergency bilge pump could not be started because of a power failure. Water was overflowing from a reserve feedwater tank and pouring into the boiler room from broken air escapes, filling pipes, and ruptured structure. With oil from the bilges on top of the water, the boiler room was secured because of a possible fire risk. When last observed, the oil had reached the floor plates.

According to survivors from the "Y" engine room, the first torpedo seemed to explode underneath that space. Half the main lighting went out and steam pressure failed. There were loud noises in the high-pressure turbine, so the turbines were stopped. Inspection indicated no damage, so the turbines were restarted, but there was no lubricating oil in the circulator. It appears that the torpedo hit aft also damaged the port inner shaft and its bearings, causing the shaft not to run true. This would explain the terrific noise heard when the turbine was restarted. According to the officer in charge, Lieutenant Watson:

After the machinist mate reported that there was no lubricating oil in the circulator, I thought it best to shut down. Someone gave orders to evacuate the engine room, but I do not know who. As there was no point in keeping the men down there, I let them come up. There was no water in the engine room . . . I went over to "Y" boiler room . . . where we tried to get the fire and bilge pump working, as the water was seeping in from the forward and aft bulkheads to the diesel room and through a reserve feed tank filling tunnel. . . . We attempted to get the emergency bilge pump going without success and we returned to the engine room. . . .

Specific details of the interior damage caused by the torpedo hit near frame 289 are lacking. It is known, however, that some manhole covers were blown off and, in particular, one on the portside of the lower deck just forward of frame 289. This later led to the partial flooding of spaces on this deck between frames 274-289 on the port side. Stateroom furniture in this area was thrown around. Below the lower deck, the port inner shaft alley, the spirit room, implement storeroom, a pump room, a fresh water tank, and port watertight compartments (voids) from frames 253-298 were also flooded.

The torpedo hits produced massive flooding on the port side. By 1150, the ship was listing 11.5 degrees to port with a trim by the stern of three feet, which later increased to five feet. The two inoperative port shafts reduced speed to 16 knots.

An attempt was made to restart the "Y" engine-room turbines with a steam connection from the "X" engine room, but the turbines had to be shut down due to heavy vibrations, the lack of a supply of lubricating oil to the main circulator, and the securing of the steam supply from "Y" boiler room because of a fire risk. The inboard shaft was trailing at 12 rpm—an indication that there was a great deal wrong with it. At this point the engine room was evacuated.

The "A" engine room (outboard starboard shaft) was unaffected during the first torpedo attack, but ventilation and lights failed in the "X" engine room (inboard

starboard shaft) since the turbogenerator which supplied power to this space was heavily overloaded. Also, one of the fans was shaken loose from its foundation by the shock response from the torpedo explosions. The machinery kept running, but because the temperature and humidity rose above the danger level, men had to be evacuated from the engine room.

In the harbour (auxiliary) machinery room the flooding was slower; bilge suction valves were opened, and the steam fire and bilge pumps were put on suction when flooding began. This type of flooding was rather a sad story, since it resulted from a ruptured ventilation trunk which supplied "B" engine room and the auxiliary engine room. The trunk was divided by a partition, but this partition was unable to resist the water pressure and finally gave way, permitting flooding water from "B" engine room to enter this space. With the lack of ventilation and with water spilling from the ventilation trunk, men were evacuated from there. The "X" turbogenerator room was also abandoned when its lighting and ventilation failed.

As a result of the flooding and damage to ship structure, the most significant casualty after the first torpedo attack was the loss of electrical power. Out of eight generators (six 330kw DC turbogenerators and two 300kw DC emergency diesel generators) only three units were in operation by the time of the second torpedo attack. The loss of power was gradual and occurred in this manner:

- Two generators were operational in the auxiliary machinery room until water poured from the ventilation trunking onto a shunt regulator of the port unit, causing an electrical fire and later partial flooding of the space. Both units had to be shut down.
- The starboard diesel generator had to be stopped because no cooling water could reach the unit, while the port diesel generator was under water. There is some evidence of unsuccessful attempts to restart the starboard unit.
- The turbogenerator in "X" action-machinery room experienced a sharp voltage drop, because it was feeding current into the flooded portside breaker rooms. The fuzes for the cross connections were not removed, as they should have been. The cause of this was a breakdown in communications; this was to be a major factor in the ultimate loss of the ship, since "X" engine room's lighting and ventilation were dependent on its electrical supply. The turbogenerator was to be lost; with it went hope of using steam for the steering.
- The turbogenerator in the "Y" action-machinery room was also under water.

This loss of electrical power crippled the entire after section of the *Prince of Wales*, darkened many compartments, cut off ventilation, severed communications (only a limited number of sound-powered telephones were on board), crippled much of the 5.25-inch battery, and interrupted the steering. Damage-control parties began to rig up emergency power leads to the steering and the after group of 5.25-inch mounts. These efforts were not completed when the second torpedo attack commenced to starboard around 1220. However, the most important casualty from the electrical failure in the stern was the elaborate counterflooding pump system.

The pumping system of the *Prince of Wales* and her sister battleships was the most elaborate type fitted to a British capital ship to that date, but, of course, it too was crippled by the power failure. A *King George V* battleship was equipped with fourteen 350-tons-per-hour pumps and four 1,000-tons-per-hour emergency bilge pumps. In addition, there were a number of 75-tons-per-hour fire and bilge pumps. Thus, the entire pumping system was capable of handling enormous quantities of water. With the after ring main dead, however, half of these pumps could not operate. Even if emergency leads could have been provided from the forward ring main, some of the

350-tons-per-hour pumps, which could operate submerged, were inaccessible due to the flooding of spaces around and above the pump rooms. This was to be a very significant development, because damage-control parties had established a flooding boundary at the middle deck by the time the second torpedo attack commenced. There were no large capacity pumps available, however, to remove the water in those areas of the stern torpedo hit. Emergency portable pumps of a significantly smaller capacity had to be used here. Some pumping was attempted in the midships portion, but the darkened ship conditions, the list and trim, and the stifling heat and humidity made access difficult, if not treacherous. Therefore, the damage-control efforts had not removed much water by the time the starboard torpedo hits were sustained. This failure to gain additional buoyancy was to be a decisive factor in the sinking of the *Prince of Wales*.

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According to the ship's officers, the damage-control parties had the situation almost under control around 1220. It takes twenty to thirty minutes for a damage-control party to determine the extent of damage, how best to control the situation, and finally to commence efforts to shore up weakened structure and reinforce hatches or doors to flooded compartments. The problem in the *Prince of Wales* was that the lack of communication caused by the power failure made it difficult for the damage-control central to know the severity of the problem. In fact, Captain Leach had difficulty in determining just what was wrong with his ship. Nonetheless, a number of temporary electrical lines were rigged aft to supply emergency power, but the second torpedo attack simply overwhelmed the crew's capabilities, and many of these lines were never connected to the equipment they were intended for. As the action took place near the equator, more ventilators than usual were open. It is probable that several ventilator systems were left open or not properly secured after the first torpedo attack, thus increasing the area of flooding. Moreover, damage control was hampered by high temperatures within the ship (92°F in living spaces and 125° or more in some machinery spaces). Also, ventilation, lights, and communications failed almost instantaneously, and the combined list and trim made access difficult. Almost every member of one damage-control party was overcome by heat exhaustion, but many returned after a short rest topside.

Minutes after the initial attack, Captain Leach ordered counterflooding to correct the heavy list. All valves in floodable compartments in the side protection system between frames 79-184 on the starboard side were opened, and repair parties concentrated on establishing the middle deck as the upper flooding boundary. Most of the work was accomplished between frames 228-242 on the port side, where conditions were the worst. By 1215, the port list had been momentarily reduced to less than a degree. Nevertheless, considerable difficulty was encountered with water gushing from ventilation trunks and air escape pipes. In many cases, this could not be stopped even though watertight fittings were installed on the middle deck. One damage-control party tried to reinforce louvers with shoring, while another tried in desperation to flatten the trunk to halt the rush of water. Despite great difficulties, some of the ventilation trunks were secured by damage-control parties. As a result of the continuing progressive flooding, the port list increased again even though hatches to major compartments already flooded were tightly closed and shored. Damage control and repair work was impeded by the list and lack of portable pumps to control the flooding.

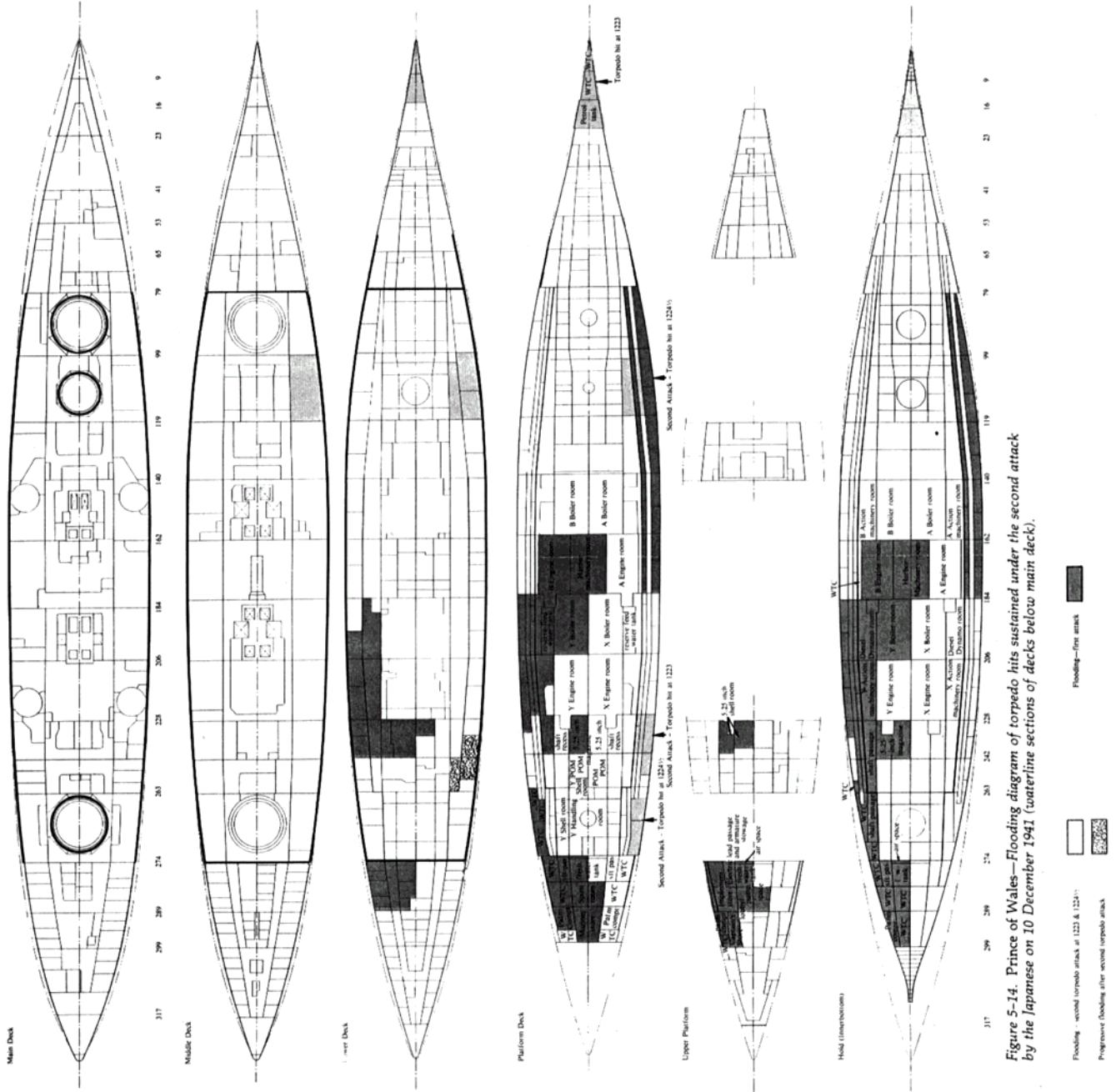
Aft, between frames 274-289, a repair party was able to establish flooding boundaries and to replace and shore the manhole cover which had been blown off in a lower deck passageway. A portable pump was being rigged to dewater spaces on this deck when a second torpedo hit on the starboard side near this area halted all activity.

By 1200 the electrical power situation, although not hopeless, was nonetheless

Figure 5-13. Prince of Wales—Flooding diagram of torpedo hits sustained under the first attack by the Japanese on 10 December 1941 (waterline sections of decks below main deck).

Key:
Flooding from first torpedo attack at 1144

Progressive flooding after torpedo hits in first attack



serious and seriously affected the gunnery. With five generators out of service, the main and secondary batteries were affected. None of the 14-inch guns were fired during the action, but their ability to be used was severely hampered by the power problem. The torpedo hits to port had disabled "Y" turret through a combination of shock damage to fittings and equipment and the absence of electrical power aft. The forward port 5.25-inch mounts were temporarily out of action, one due to a jam and the second from a lack of power. The after group of 5.25-inch guns (port and starboard) were out of action due to their magazines being flooded and a lack of power. The after 5.25-inch gun on the starboard side was temporarily out of action due to a power failure. Power was restored to the forward mounts, but the list prevented them from training. More significantly, even at the maximum depression these guns could not fire at the Japanese planes when the second torpedo attack commenced because of this problem and the inability to depress the guns to hit the Japanese planes, which were at a very low height. The pom-poms, Oerlikons, and the single Bofors were unaffected until some twenty minutes after the first torpedoes struck, when the list became great enough to impair their effectiveness. Many of the pom-poms, however, had difficulty with defective ammunition clips, which caused shells to jam, and this prevented many pom-pom mounts from keeping up a sustained rate of fire.

One Type 282 radar and three of the working Type 285 sets were out of action due to a shock response to the explosions, which literally shook the ship, and the resulting loss of electrical power. Two of the Type 285 radars were later returned to service, but the gunnery-control radar (282) was permanently out of action.

The power failure disabled both steering engines. Damage-control parties quickly managed to rig some temporary leads to restore power aft to some vital equipment. Damage-control central was advised that the steering-gear motors would be available once the temporary leads were energized. They were never used, and an order was given at 1217 that the port steering-gear motor was not to be started. In the meantime, the steam connection from the "X" engine room for the emergency steering was connected. This did not last long; lack of ventilation in the "X" engine room limited men to five-minute relays and the turbopump could not continue in operation. Two of the engine room ventilating fans were shifted off their foundations by a shock response to the first torpedo explosions. The resulting power failure left the space without lights or ventilation. With the port shafts not functioning and the ship yawing erratically, the "out of control" signal was hoisted at 1210. Meanwhile, damage-control parties worked with the aid of headlamps in stifling heat. When it finally became necessary to evacuate most of the machinery spaces and boiler rooms—the latter furnishing the steam for the electrical power—the possibility of controlling the flooding was further reduced.

Second torpedo attack. At 1156 seven torpedo bombers made a second attack on the *Repulse*; all torpedoes missed. It is also possible that another group of eight Japanese bombers dropped their torpedoes at extreme range. Two minutes later six high-level bombers (those who participated in the initial assault on the *Repulse*) attacked from a height of 12,000 feet; all their bombs missed. Finally, one torpedo bomber closed at 1202 on the *Repulse*, but his torpedo missed. The *Repulse* now closed the *Prince of Wales* to provide assistance. At 1158 Captain Tennant had already radioed to Singapore that they were under heavy attack and needed tugs to tow the *Prince of Wales* to port.

At 1219, with the ships only 900 yards apart, twenty-six planes grouped to attack the *Prince of Wales* and *Repulse*. Six planes attacked the *Prince of Wales*, while eight planes attacked the starboard side of the battlecruiser. The *Repulse* made a tight turn, but three other planes from a group which had attacked the *Prince of Wales* made a

torpedo attack on the battlecruiser's port side. With the ship now committed on a course to evade the eight torpedoes dropped earlier, she could not maneuver to avoid this attack. One torpedo struck amidships on the port side. At 1225 nine torpedo bombers attacked the *Repulse* from all directions; two were shot down, but there were at least four more torpedo hits, jamming her rudder and leaving her listing heavily to port. At 1232 the ship turned over and sank stern first. The *Vampire* and *Express* picked up her survivors.

Torpedo damage. The *Prince of Wales*, unable to maneuver during this attack, took one torpedo hit abreast of the forward breakwater (approximately frame 9), another near frame 236 at 1223, and two more about 90 seconds later—one at frame 109 (near "B" turret) and another at approximately frame 280 (see Figure 5-12). All were spaced along her starboard side. Fortunately, two torpedoes missed.

The hit in the bow caused the immediate flooding of the two peak tanks and possibly the petrol tank abaft them. There was no fire, so it is believed that the gasoline tanks themselves did not explode. The torpedo explosion tore a jagged hole about twenty feet in diameter right through the ship and fractured the stem post.

The most devastating hit in this attack occurred just abaft "Y" turret, jamming the starboard outer shaft and leaving only the starboard inner shaft in operation. In 1966 divers examining the wreckage found the outer shaft had crossed over the inner shaft and had wedged its propeller between the inboard shaft and the hull. There was a jagged hole some six feet in diameter slightly forward of where the two shafts crossed. Evidently the torpedo hit the shaft strut or the outer shaft. The fact that the outer shaft was bent inboard and wedged between the outer shaft and the shell meant that the shaft strut would have to fail. Also, the turbine in "A" engine room came to a complete halt.

Another torpedo struck just forward of "Y" turret where the inner and outer voids of the torpedo protection system were empty. These voids (frames 228-234) flooded entirely. Flooding occurred in the stokers' washroom on the lower deck. Definite evidence of flooding in the shaft alley immediately inboard of the holding bulkhead or groups of compartments bounding this area was never firmly established, since many of these areas had been evacuated shortly after the first torpedo attack. It is known, however, that the "X" action-machinery room (frames 206-228) and the starboard diesel generator room (frames 184-206), as well as breaker room 13 above, remained watertight. Some water did enter breaker room 15.

Conditions in the *Prince of Wales* during and after these two torpedo attacks were vividly described by Warrant Officer W. Winchester, who was in command of "A" engine room at the time:

Times of incidence cannot be given as I had no watch and lost my sense of time. My narrative will begin from the first "hit." A loud bang was heard, followed by a terrific shaking which lasted a minute or two. From my gaugeboard I could see that all was well in my turbine. To make sure, I sent my machinist mates to examine machinery for fractures. None were found. I decided from a morale point of view to make a visit to "A" boiler room, as we had a decided list to port. The boiler-room machinery was working well, and personnel there were in good spirits. Leaving this space, I met Lt. D. B. H. Wildish who passed an order, "counterflood the starboard side forward, 140-162, inner and outer watertight compartments and armor shelf compartments." Hearing this order and being familiar with the flooding arrangements, I asked Lt. Wildish if I should do it. He replied, "Yes." With the Chief Machinist Mates I carried out the order, tested the Premescator, and reported by telephone to Damage Control Headquarters. After telling my commanding officer what I had done, he asked me to flood compartments from frames 162-184 on the starboard side. Upon completing this, I attempted to inform Damage Control Headquarters, but the phones had gone dead. Shortly after

completing the counterflooding, the second torpedo attack began. A machinist mate reported that "A" shaft had ceased turning [authors note—this occurred at 1224]. We could not move the turbines and the ventilation had failed, so I gave the order to leave the auxiliary machinery in the space running and evacuate "A" engine room. At this point two machinist mates collapsed from heat exhaustion and one became hysterical. They were moved to the mess deck and revived. Around this time a terrific explosion was heard, and its blast came through the mess deck around frame 140 [authors' note—this occurred from a bomb hit at 1244]. I was joined by another officer and a chief machinist mate in a discussion on what should be done despite being exhausted from the heat. I decided that nothing else could be done, as there were no fires visible and all machinery was operating with the exception of the turbines. At this time the smoke and fumes became thick and stifling so that men coughed and choked. It even blacked out the lights. The ship was heeling to port and it became so unbearable that I passed an order to evacuate the boiler and auxiliary machinery rooms, leaving all machinery in operation.

The torpedo which struck near frame 109 caused particularly heavy damage, as a huge plume of oil and water shot up alongside "B" turret. The inner voids had been flooded, and Captain John Leach had reluctantly decided to also flood the outer voids to correct the port list. By flooding these spaces he knew that he was reducing the efficiency of the side protection system, but this was offset by the need to reduce the port list and the trim aft which was making it difficult to operate the antiaircraft guns. Washrooms on the lower deck and living spaces on the middle deck were flooded by a mixture of oil and salt water. Breaker room 1 had some oil flooding through a hatch which was opened for its crew to escape. Water in the voids of the torpedo protection system prevented it from functioning as designed, and the full force of venting the explosive passed into the ship. This may also have been the cause of the collapse and breakage of gear in the cordite and shell-handling rooms for "B" turret and the 14-inch transmitting station. The middle deck had an irregular hole some four feet in diameter at frame 109 over a washroom. This is believed to have been caused by the projectile effect of a degaussing generator in the latter compartment.

The combination of the port and starboard torpedo hits between frames 280 and 290 caused a severe amount of damage and flooding. There is evidence of considerable flooding, wreckage, and fumes in the stern; probably a large portion of the ship was open to the sea abaft bulkhead 299. The steering compartment was now flooded, and spaces as high as the middle deck were beginning to flood uncontrollably. One survivor likened the flood to an incoming tide. In addition, it is the authors' opinion, based on the amount of charge in the torpedo warhead and the location of the torpedo hit, that the starboard torpedo hit aft was the decisive hit in the loss of ship buoyancy. It negated all the damage-control efforts in this section of the ship, and the intact buoyancy of the ship was so substantially reduced by stern flooding that the ship began a slow plunge by the stern.

As water flooded the starboard side in the damaged area, the port list reduced to less than a degree, but the ship settled deeper by the stern. Speed was reduced to 8 knots, with one shaft, and the "X" engine room was still in service. It had been evacuated after the first torpedo attack, but the turbines were kept running by men going below in relays. Repair parties were unable to cope with the flooding which occurred after these hits; by 1245 the quarterdeck was awash. (For flooding and location of torpedo hits during the second attack, see figure 5-12 and 5-14.)

Bomb damage. Beginning at 1241, eight bombers dropped seven 1,100-pound bombs from 8,400 feet, with several near misses, one of which was reported to have exploded 15 feet from the starboard side amidships. Five of the eight planes were damaged by

the shellfire of those 5.25-inch guns still in action (three of the four forward mounts). One bomb penetrated the catapult deck near or through the catapult mechanism on its port side and exploded on the lower deck. Fragments riddled the ship's sides, air intakes, and uptakes above the armor deck, causing some additional flooding as the ship settled deeper into the water. The side scuttles were distorted and let water into topside areas; large free surface effects developed, further reducing stability. A fire broke out in an office on the catapult deck, and the port aircraft crane was wrecked. The catapult deck was blown upwards, and the explosion caused heavy casualties among some 200-300 men in an emergency first-aid station known as the Cinema Flat. Splinters caused some casualties in a shell-handling room on the starboard side.

Below the point of the bomb's explosion was the "X" boiler room. The bomb riddled its uptakes and intakes, forcing its shutdown. Some of the fumes and flash were injected into this boiler room, causing some casualties to its crew. This put the "X" engine room out of operation until boilers for the "A" engine room were cross-connected to supply steam. The crew of the "X" boiler room were evacuated.

The Prince of Wales sinks. By 1251 the situation was very grave. At that time there was an estimated 18,000 tons of water in the ship, and with the stern going down rapidly, it was feared she would be lost. Only the "X" engine room was in operation, but it had no lights or ventilation. Steam had been connected to the steering-gear compartment, but when that space flooded, the ship was out of control.

Finally, shortly after 1300 the bridge ordered the "X" engine room to stop the turbines. As far as the armament was concerned, only "A" turret remained capable of action, and a single starboard 5.25-inch mount (S2) was in action. The port pom-pom battery was out of action due to the large list to that side. At 1315 the list suddenly began to increase to port.

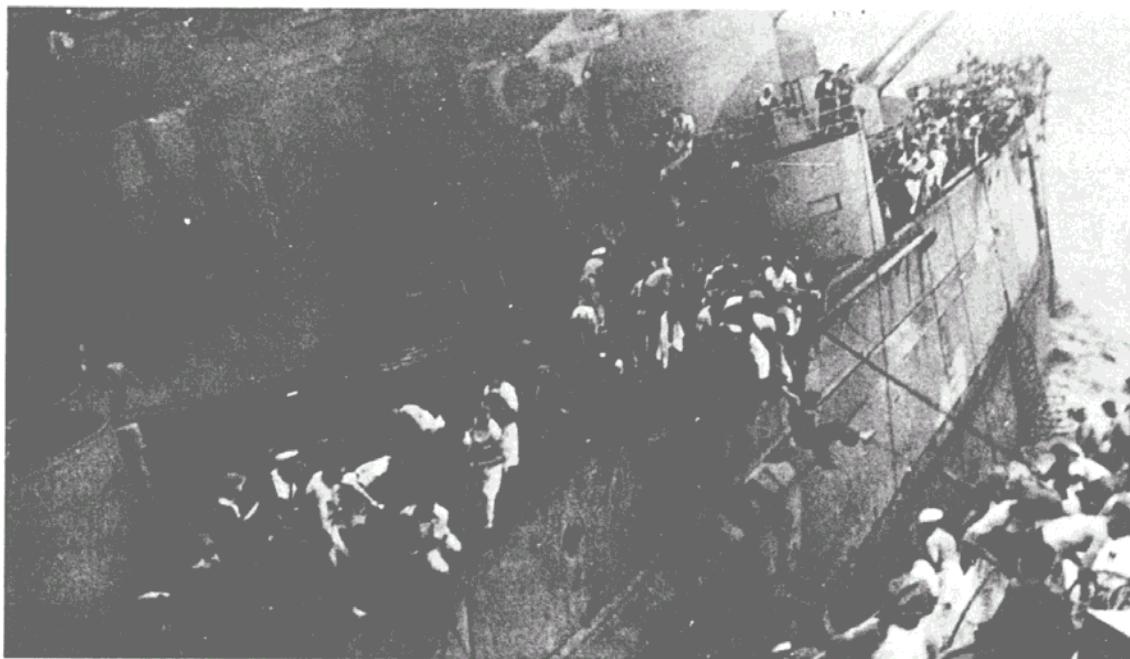
At 1320 the *Prince of Wales* suddenly lurched to port and capsized so rapidly that the bilge keel almost overturned the destroyer *Electra*, which had been alongside taking on survivors and now was moving away. The ship remained bottom up before finally passing below the water surface.

The *Prince of Wales* sank in less than two hours after the first torpedo attack; the *Repulse* lasted less than fifteen minutes. In the two ships, a total of 870 men were lost, including Admiral Phillips and Captain Leach.

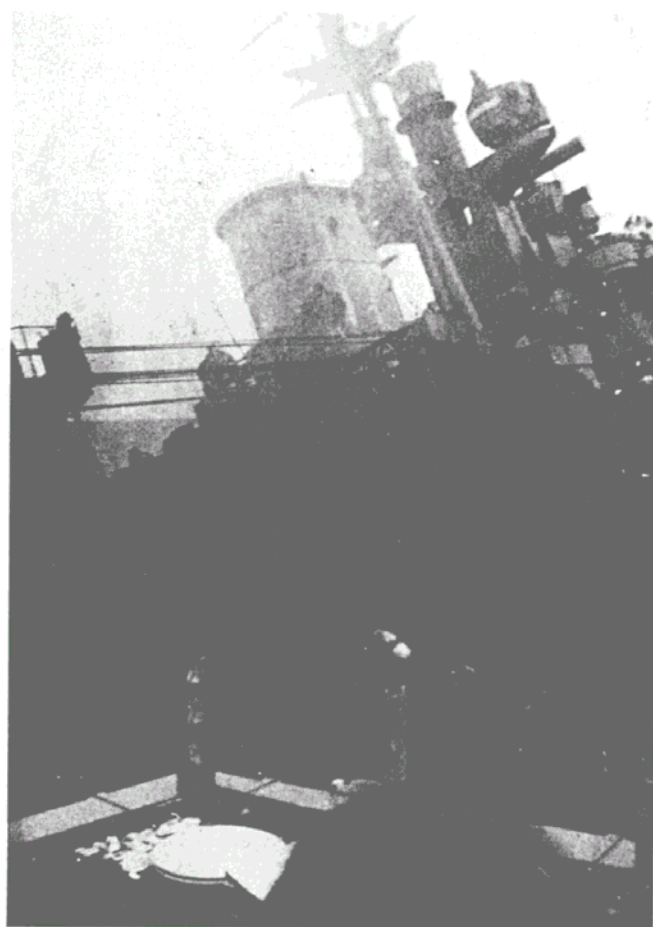
December 10, 1941, was a turning point in the history of the battleship. Modern aircraft had demonstrated that the battleship, like any other warship, was liable to destruction by air attack unless properly defended.

The loss of these two ships profoundly shocked Great Britain. Subsequent investigations and their findings affected surviving ships of the class, as well as the design and arrangement of the *Vanguard* and the later redesign of the *Lion*-class ships. When *King George V*-class ships underwent overhauls during World War II, changes were made in their ventilation systems, salvage pumping, communications system (use of sound-powered telephones), the distribution and number of watertight doors and hatches, and compartmentation (installation of trunked accesses to important spaces inside and outside the armored citadel).

The Naval Construction Department formed a committee to inquire into the operational circumstances and the technical reasons why the ships sank, with particular attention to the *Prince of Wales*, as she represented the latest thinking in British battleship design. The number of hits in the first torpedo attack was never firmly established, but it was concluded that damage sustained in that attack eliminated the ship as an effective fighting unit. Without further torpedo damage she might have survived, but her loss of maneuverability and much of her defensive power made her an easy target. Furthermore, conditions in the severely damaged ship, plunged suddenly



The destroyer Electra has come alongside on the starboard side amidships of the Prince of Wales to embark survivors. Sailors abandon ship as the battleship begins to capsize to port. Note the water pouring out of the ship in way of torpedo damage in the bow. (Royal Navy, HMS Excellent)



The Prince of Wales is shown listing heavily to port. A few minutes after this photograph was taken, the battleship capsized to port and sank, taking Captain Leach and Admiral Phillips with her. (Royal Navy, HMS Excellent)

into darkness by battle, put a very severe strain on the nerves of young and inexperienced men, who comprised the majority of the complement. As a result, all too understandably, self-survival and preservation came before discipline, which led to hatches and watertight doors being left open. This prevented the establishment of a flooding boundary and ultimately led to the uncontrollable progressive flooding.

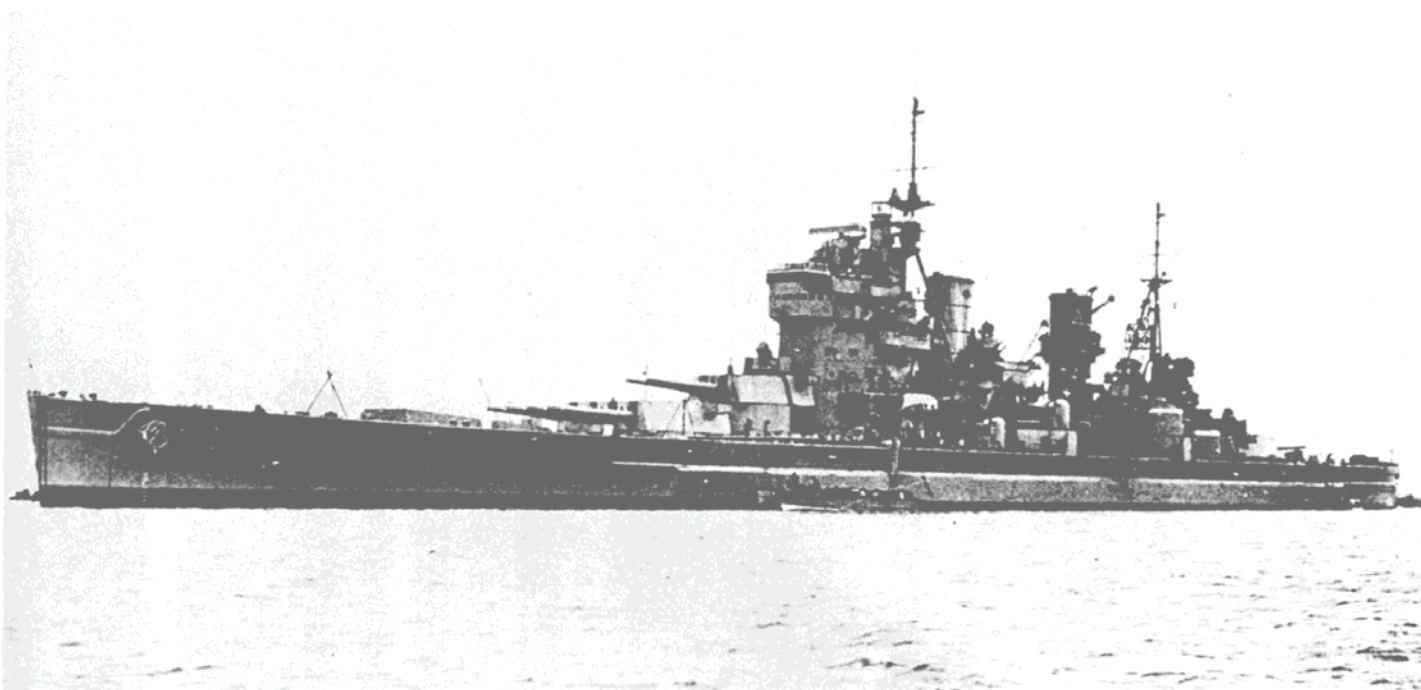
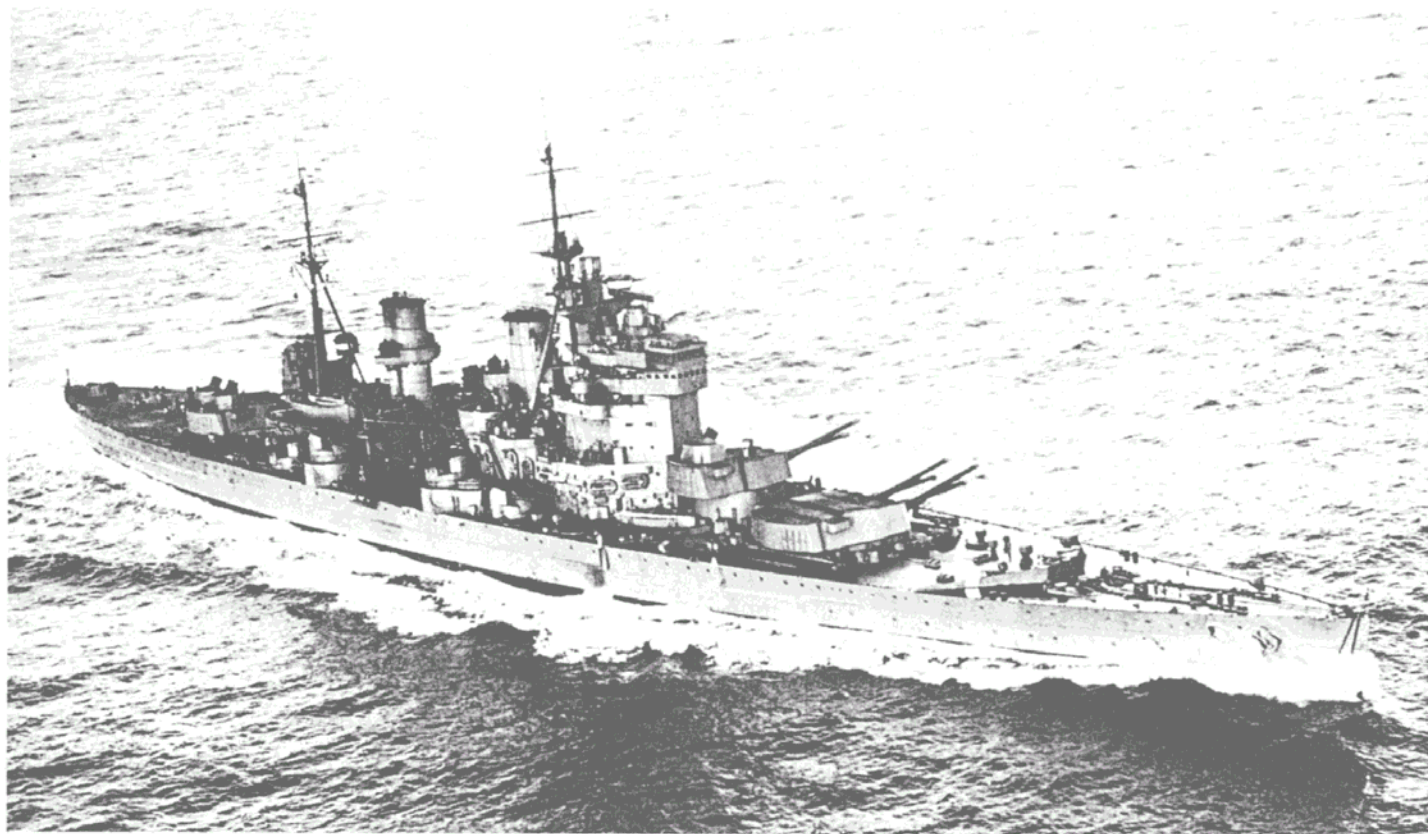
King George V—Operational History. The keel of the *King George V* was laid at the Vickers Armstrongs Shipyard, Walker-on-Tyne, on 1 January 1937, the first ship to be constructed since the yard had reopened. The ship was launched on 21 February 1939 and completed on 11 December 1940. Official power trials followed immediately off the Orkney Islands.

The first duty of the ship was to carry Lord Halifax to the United States to assume the post of ambassador. During early March 1941, the *King George V* first fired guns in combat while screening a raiding force on the Lofoten Islands; targets were German reconnaissance aircraft at very long range. Later that month, the ship escorted convoys from Halifax, as the *Gneisenau* and *Scharnhorst* were at large in the North Atlantic. Later she searched for the German ships, but without success.

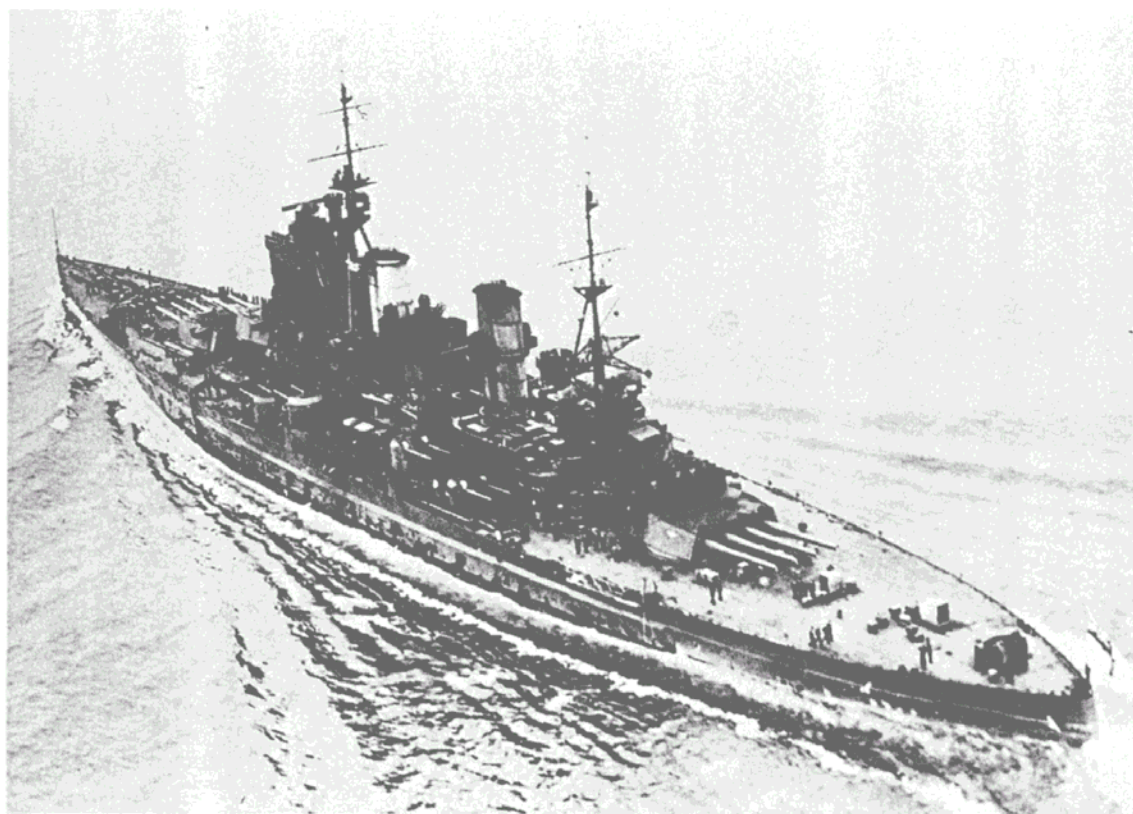
Pursuit of the Bismarck. When the *Bismarck* broke out into the Atlantic Ocean, the *King George V* sailed on 22 May in company with the *Victorious* and eleven cruisers and destroyers to support the cruiser patrols off Iceland. The *Repulse* joined up early the next morning. Admiral Sir John Tovey commanded the force, with the *King George V* as flagship. The *Prince of Wales* and the *Hood*, under the command of Vice Admiral L. S. Holland, were en route to Iceland but altered course for an intercepting position south of the Denmark Straits on the basis of a contact report by the *Norfolk*. The morning of 24 May, when the *Prince of Wales* and the *Hood* engaged the *Bismarck*, the *King George V* was still 300 to 400 miles south and east. The *Hood* was sunk, the *Prince of Wales* was damaged and forced to retire, and the Germans continued southward. The British force changed course, planning to intercept them the next morning. Later in the day, the *Victorious* launched an air attack, but only one torpedo hit was made on the German battleship, and it failed to slow her.

Early on 25 May, radar contact with the *Bismarck* was lost. The British sailed westward until around daybreak, when Admiral Tovey turned his forces northeastward due to a faulty plot of the direction-finder lines of bearing of the *Bismarck*'s last reported position. After some anxious discussions, Admiral Tovey decided to converge all forces toward the French coast in pursuit of the *Bismarck*. He believed that the Germans would head for Brest just as they had previously with the *Scharnhorst* and *Gneisenau*. Despite considerable maneuvering and high-speed searching, the British failed to locate the *Bismarck* until 1030 on 26 May, when a Coastal Command Catalina sighted her, headed for Brest as expected. The *Rodney* and *King George V* were still about 125 miles away and some distance apart, and the *Bismarck* had a 50-mile lead on the *King George V*. The carrier *Ark Royal* was ordered to launch an air attack, and at 2225 her torpedo planes damaged the *Bismarck* enough to slow her down and force her to turn into the sea, away from safety, making it possible for the British to overtake her at a more economical speed. At 1500 the *Rodney* joined the *King George V* and they maintained 22 knots—about maximum speed for the older *Rodney*. The *King George V* had only 32 percent of her fuel left, and the *Rodney* had only enough to continue the chase at high speed until 0800 the following day.

During the night, five destroyers shadowed the German ship, but her accurate fire kept them at a distance. Admiral Tovey signaled his battle plan to the *Rodney* just



The King George V is shown in two photos above, which were all taken during 1941. These views clearly show the new Type 271 radar surface search set and the 20-barreled U.P. projectors located on "B" and "Y" turrets and the fantail. The latter were unsuccessful AA unguided rocket launchers; they were subsequently replaced by multibarreled pom-poms. A distinctive feature of this ship was the externally mounted degaussing cable, which was internal on the other four ships. (Imperial War Museum; Wide World)

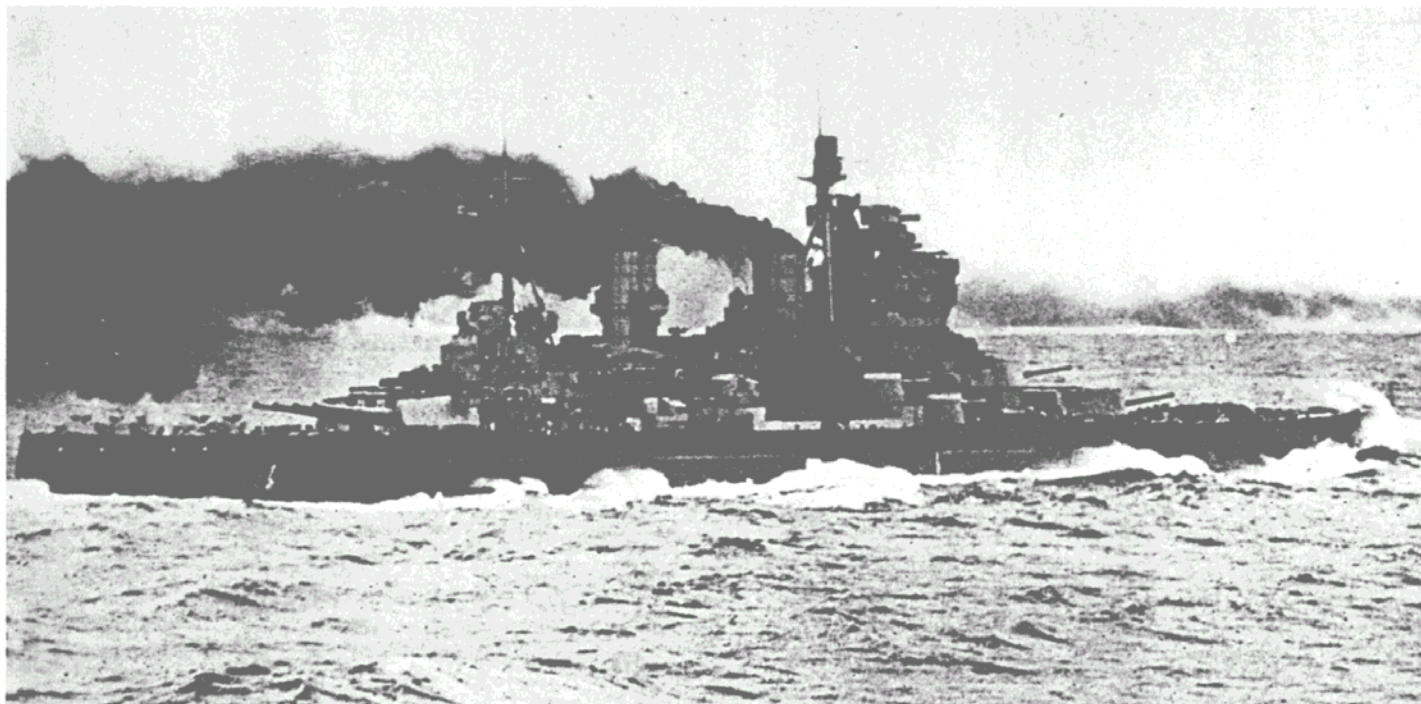


This photo was taken on 24 January 1941 in Chesapeake Bay, when the *King George V* brought the British ambassador, Lord Halifax, to Annapolis, Maryland. (Imperial War Museum, Wide World, U.S. Navy)

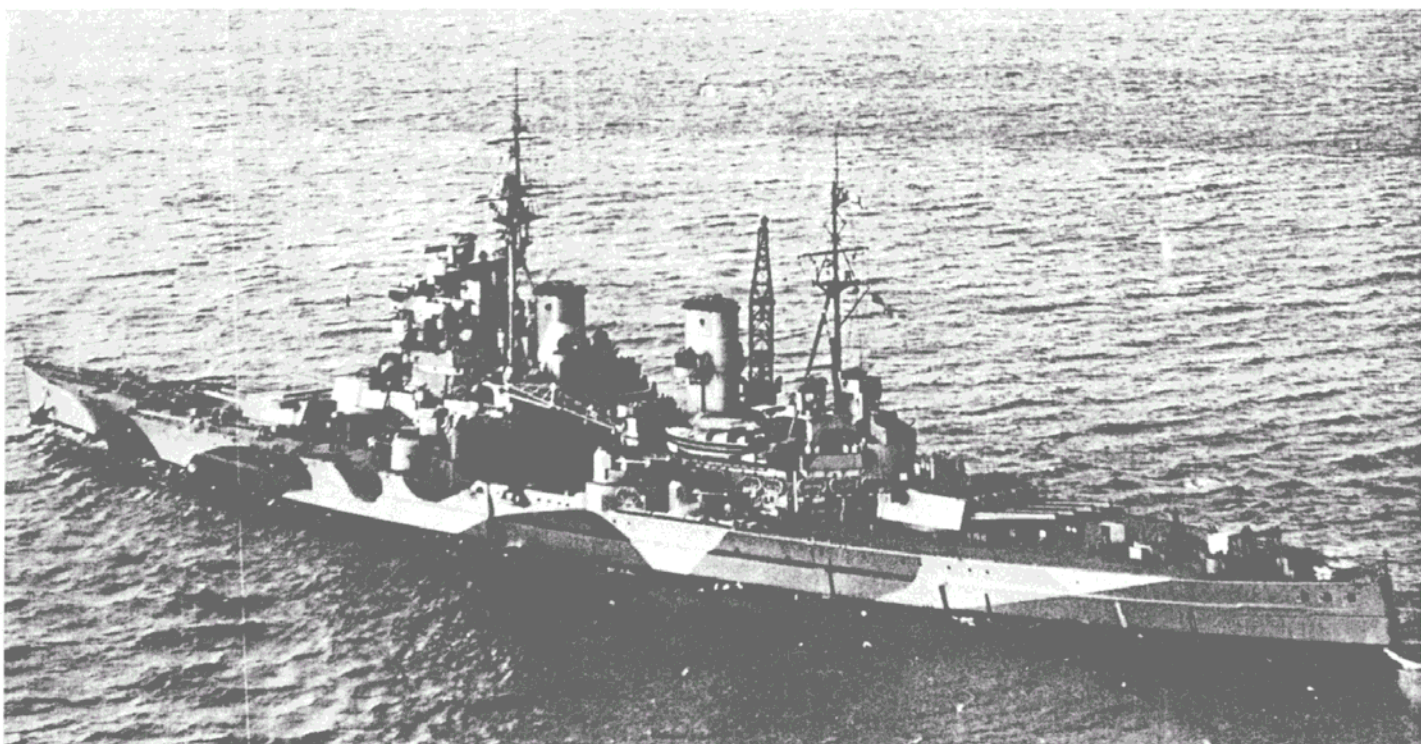
before sunrise on 27 May: She was free to maneuver independently of the flagship as long as she conformed generally to the movements of the *King George V*. Both ships were to close range as quickly as possible to 15,000 yards, then turn for broadside fire.

Action with Bismarck. At 0815 the *Norfolk* spotted the *Bismarck* and turned away, out of range. She soon sighted the other British ships off her starboard quarter, and informed them that the *Bismarck* was about 50,000 yards to the southwest. By 0843 the *King George V* had the *Bismarck* in sight, at 20,500 yards. Four minutes later the *Rodney* opened fire, the *King George V* followed suit in less than a minute. The *Bismarck* answered almost immediately, straddling the *Rodney* on her second salvo. At 0854 the *Norfolk* joined in at 20,000 yards and soon scored a hit on the *Bismarck*'s foretop. Meanwhile, the *Rodney* had moved in to 6-inch gun range and had a straddle on her third salvo. Her next salvo produced a hit. The *Bismarck*'s fire-control and radar gear were knocked out by direct hits and her gunfire became so inaccurate that it no longer hampered the *Rodney*.

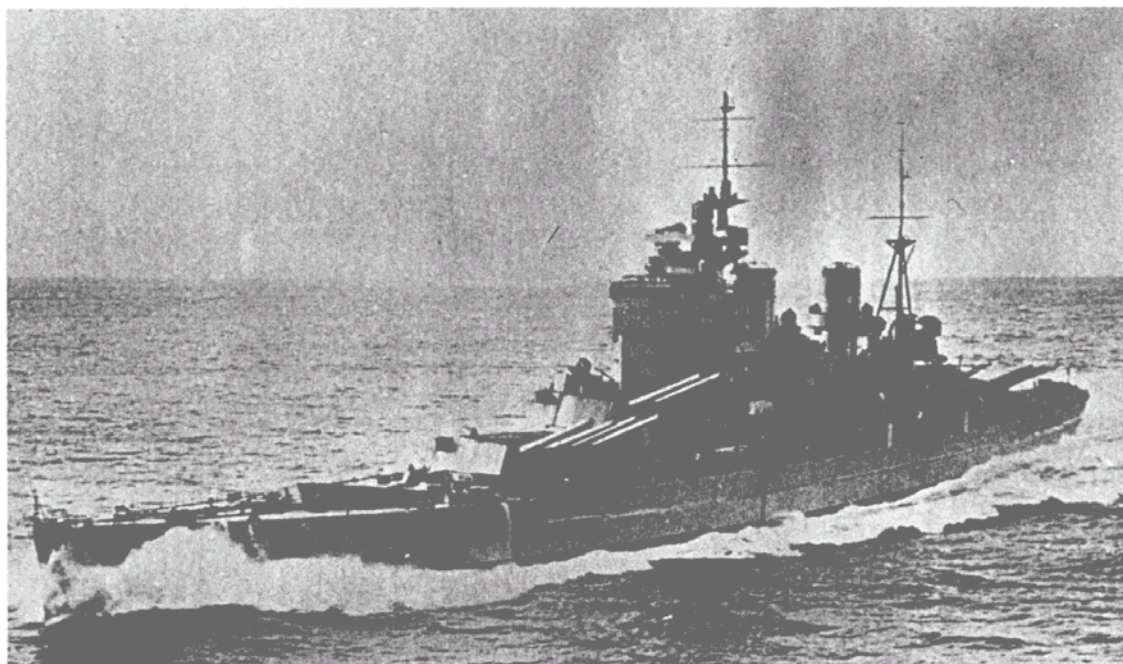
By 0859 the *King George V* had closed to 16,000 yards and all her 14-inch guns were firing; the *Rodney* was firing full 16-inch salvos. The *Bismarck* concentrated all her remaining guns on the *King George V*, but only an occasional shell came close. At 0903 the *Dorsetshire* joined the battle at 10,000 yards, but checked fire nine minutes later because of difficulty in spotting the fall of shot, caused by the large number of shell splashes from the ships firing at the *Bismarck*. At 0914 the *King George V*, at 12,000 yards, had opened fire with her 5.25-inch guns, and the *Rodney* had moved in to 8,500-9,000 yards. At 0927 a shell hit the *Bismarck*, penetrated to the hydraulic



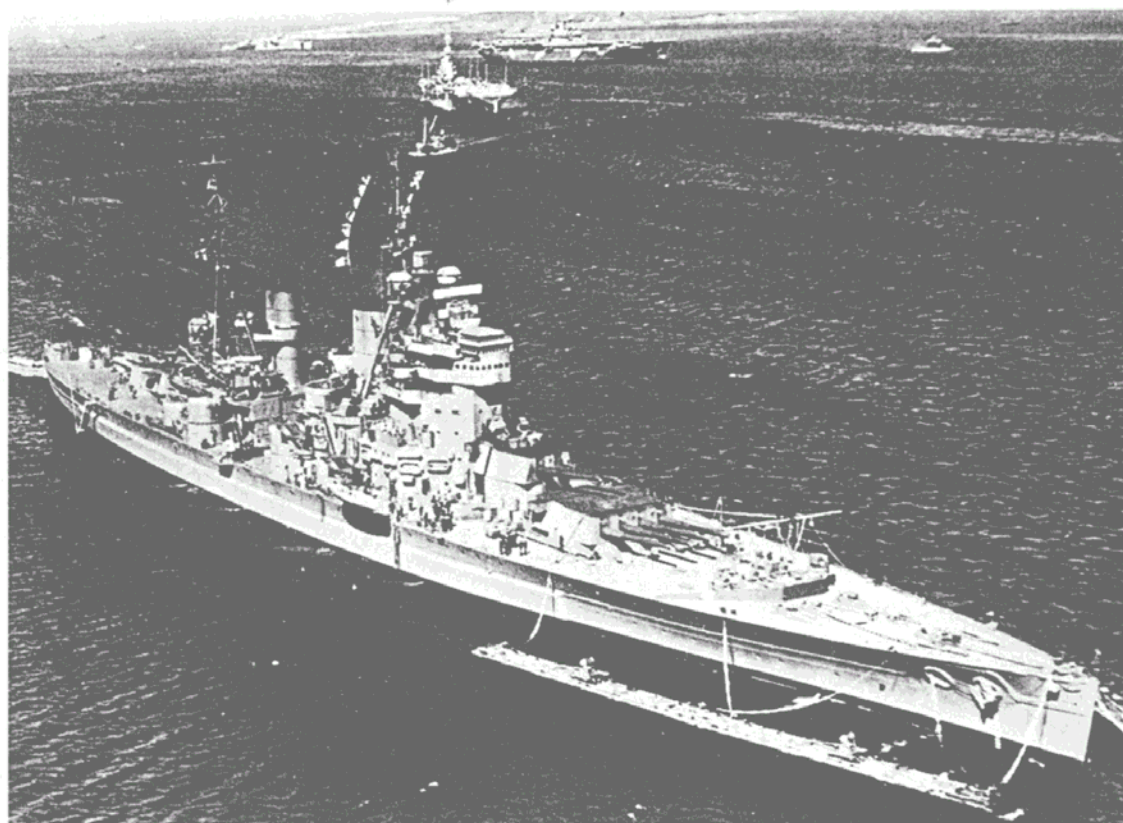
The King George V class battleships were designed to permit "A" turret to fire directly forward with the guns at zero elevation. This design feature led to seakeeping problems and difficulties with severe spray formation forward, even in moderate sea conditions, as can be clearly seen in this photograph. (Henri Le Masson)



This wartime view shows the King George V in one of her several camouflage schemes. The Royal Navy battleship had at least four different schemes applied during World War II. (Royal Navy)



A striking view of the King George V at speed, with her main battery trained to port. The modest freeboard and spray formation problems forward are apparent. (Wide World)



The King George V in March 1942 at Scapa Flow, with ships of the Home Fleet. In May 1941, in company with the Rodney, the King George V battered the Bismarck to a state of defenselessness, at which time the Germans scuttled their doomed ship. The USS Wasp, operating with the Home Fleet, lies at anchor in the background.

machinery for turret Anton and disabled it, causing the guns to run down to maximum depression. Her topsides were wrecked, and a large fire burned amidships.

By that time the *King George V* was having trouble with her main battery, and every gun missed at least one salvo due to failures in the safety interlocks for antirash protection. The *Bismarck* then could fire only two guns in turret Caesar, sporadically, and by 1000 all her guns were silent. The *Rodney* was still firing full nine-gun salvos at 5,000 yards (point-blank range), with three or four hits per salvo. She closed range to 3,000 yards and fired her last torpedo which, if it hit (but this was not confirmed by survivors), would have been the only time in history that one battleship torpedoed another. At 1015 the British broke off the action, as it would have taken a disproportionate number of shells to sink the *Bismarck*, and their fuel reserves were low. The *Bismarck* was still afloat, but crippled and burning, and men could be seen jumping overboard. About fifteen minutes later, the *Dorsetshire* put two torpedoes into the wreck. The Germans had detonated scuttling charges a few minutes earlier. The *Bismarck* sank at about 1040, 27 May. Survivors, and British logs, variously state the time from 1035 to 1115. More than 2,000 men went down with the ship; slightly over 100 were rescued. There were no survivors from the devastated forward superstructure.

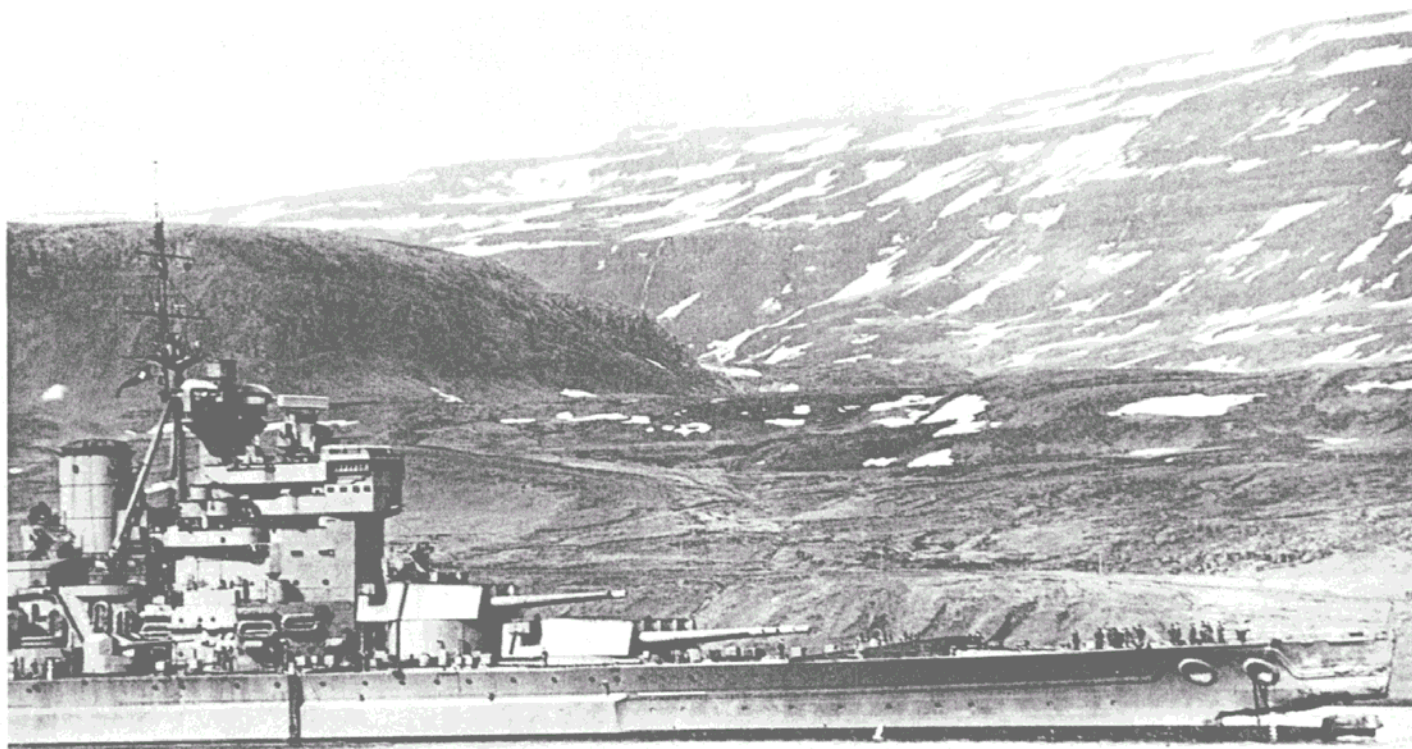
Both British battleships had little fuel left and returned to port at very low speed, escorted by eleven destroyers to guard against German air or submarine attack. The next day, after the escort was reduced to three destroyers, four German planes did attack but made no hits. Both the *King George V* and *Rodney* made port safely, but the destroyer *Mashona*, sent ahead to refuel, was bombed and she sank.

Collision damage. After repairs and adjustments to her 14-inch guns, the *King George V* attacked German shipping in Glom Fjord, Norway, in October 1941. She then covered convoys to Russia until 1 May 1942. On that day, operating with the USS *Washington* as escort to Convoy PQ 15, she collided with the destroyer *Punjabi*, which had maneuvered to avoid a mine and crossed her bow in a dense fog. The *Punjabi* was cut in two, and the *King George V* had 40 feet of her bow badly damaged. Depth charges from the sinking destroyer exploded as the stern of the battleship passed over. Shock from the explosions tossed about loosely secured equipment, damaged the electrical system, damaged machinery foundations, and tripped circuit breakers, especially on the turbogenerators—with the consequent loss of power. The ship entered the Gladstone Dock in the Liverpool Dock System on 9 May for repairs by Cammell Laird, and returned to Scapa Flow on 1 July 1942 for resumption of convoy escort duty.

In the spring of 1943, south of Iceland, the ship encountered a severe storm with winds near hurricane force and seas estimated at 45-50 feet high. Speed was cut to 6 knots because of the large amount of water being shipped over the bow due to the lack of sheer forward. A cutter lashed down amidships was carried overboard by one wave that damaged other boats on deck and partially flooded the "B" engine room through a ventilation trunk.

In May, the ship sailed to Gibraltar as part of the bombardment force for the invasion of Sicily. With the *Howe*, she shelled the Levanzo and Trapani Islands. In September the battleship escorted a naval force which occupied the Italian naval base at Taranto, later escorting surrendered Italian ships from Malta to Alexandria. After bombarding the Germans during the Salerno operation, the *King George V* returned to the United Kingdom.

Pacific operations. From March to June 1944, the *King George V* was in Liverpool for an overhaul, which included the installation of additional radar gear and more anti-aircraft guns and improved accommodations and ventilation. On 28 October, after train-



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On 1 May 1942 the King George V collided with and sank the destroyer HMS Punjabi during a dense fog. The damaged battleship is shown here anchored in Iceland, shortly after the tragedy. The bow was damaged for some 40 feet during the collision. (Imperial War Museum)

ing at Scapa Flow, she sailed to join the new British Pacific Fleet under Admiral Sir Bruce Fraser. Her first action in the Pacific was participation in the seaborne air strike against Japanese oil installations in southern Sumatra.

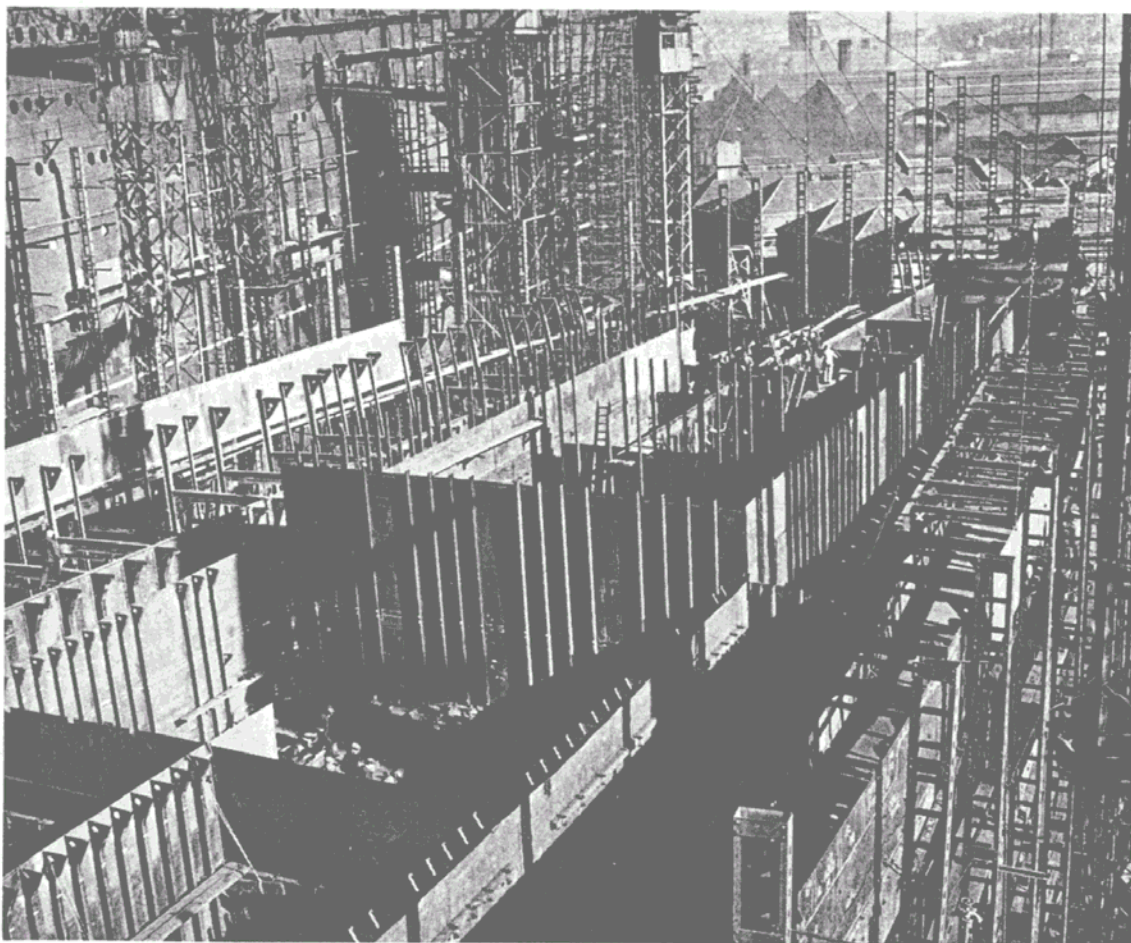
In 1945 the *King George V* served with U.S. naval forces in the Pacific. During the Okinawa campaign, the battleship supported four fast carriers of the British Pacific Fleet. On 4 May 1945 she led battleships and cruisers in a forty-five minute bombardment of Japanese air facilities in the Ryukyu Islands. On 17 July the ship joined Task Force 37 and took part in the first Allied battleship assault on the mainland of Japan. Her last offensive action was a night shelling of Hamamatsu on the south coast of Honshu on 29-30 July 1945. The subordinate position of the battleship by that time was shown by the fact that the bombardment was possible only with air cover.

The *King George V* was in Tokyo Bay for the Japanese surrender on 2 September 1945, then returned to the British Isles. In January 1946 she carried the Duke and Duchess of Gloucester on an official visit to Australia, returning to Portsmouth in March. She was flagship of the Home Fleet until December 1946, when she became a training ship.

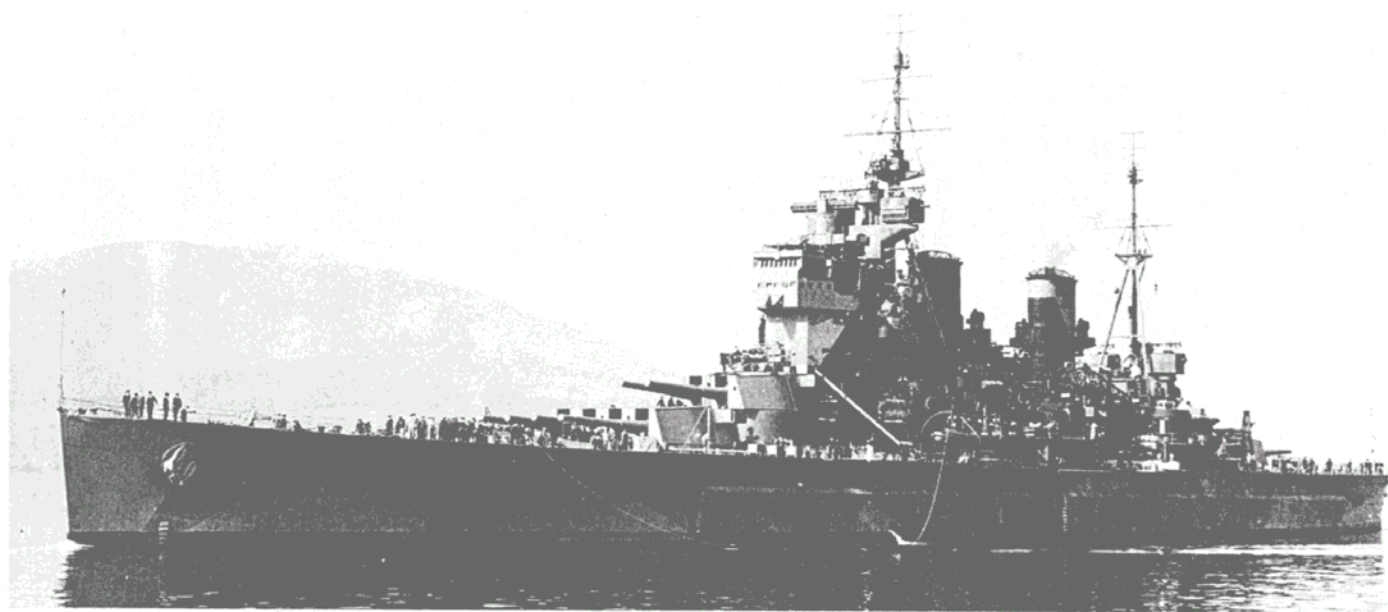
Final Disposition. The *King George V* went into reserve in 1950. In December 1955 she was downgraded to extended reserve and two years later she was ordered scrapped. She was broken up by Arnott Young and Co. at Dalmuir.

Duke of York—Operational History. The keel of the *Duke of York* was laid at John Brown and Company, Clydebank, on 5 May 1937. The ship was launched on 28 February 1940, and completed on 4 November 1941. She then joined the Home Fleet at Scapa Flow for training.

In mid-December 1941, the *Duke of York* embarked Prime Minister Winston Churchill for a trip to the United States to confer with President Roosevelt. She arrived at Annapolis, Maryland, on 22 December 1941, made a shakedown cruise to Bermuda in January, and departed for Scapa Flow on 17 January. On 1 March 1942 she provided close escort for convoy PQ 12 in company with the *Renown*, *Kenya*, and six destroyers. On 6 March that force was reinforced with the *King George V*, *Victorious*, *Berwick*, and six destroyers, since Admiral Tovey believed that the *Tirpitz* might attempt to intercept the convoy. On 6 March the German battleship put to sea and was sighted by a British submarine around 1940. No contact was made except for an unsuccessful aerial torpedo attack by planes from the *Victorious*. From March through October she covered convoys to Russia, then took part in the Allied invasion of North Africa. She then returned to northern waters, where the presence of the *Tirpitz* demanded extensive coverage of Russian-bound convoys.

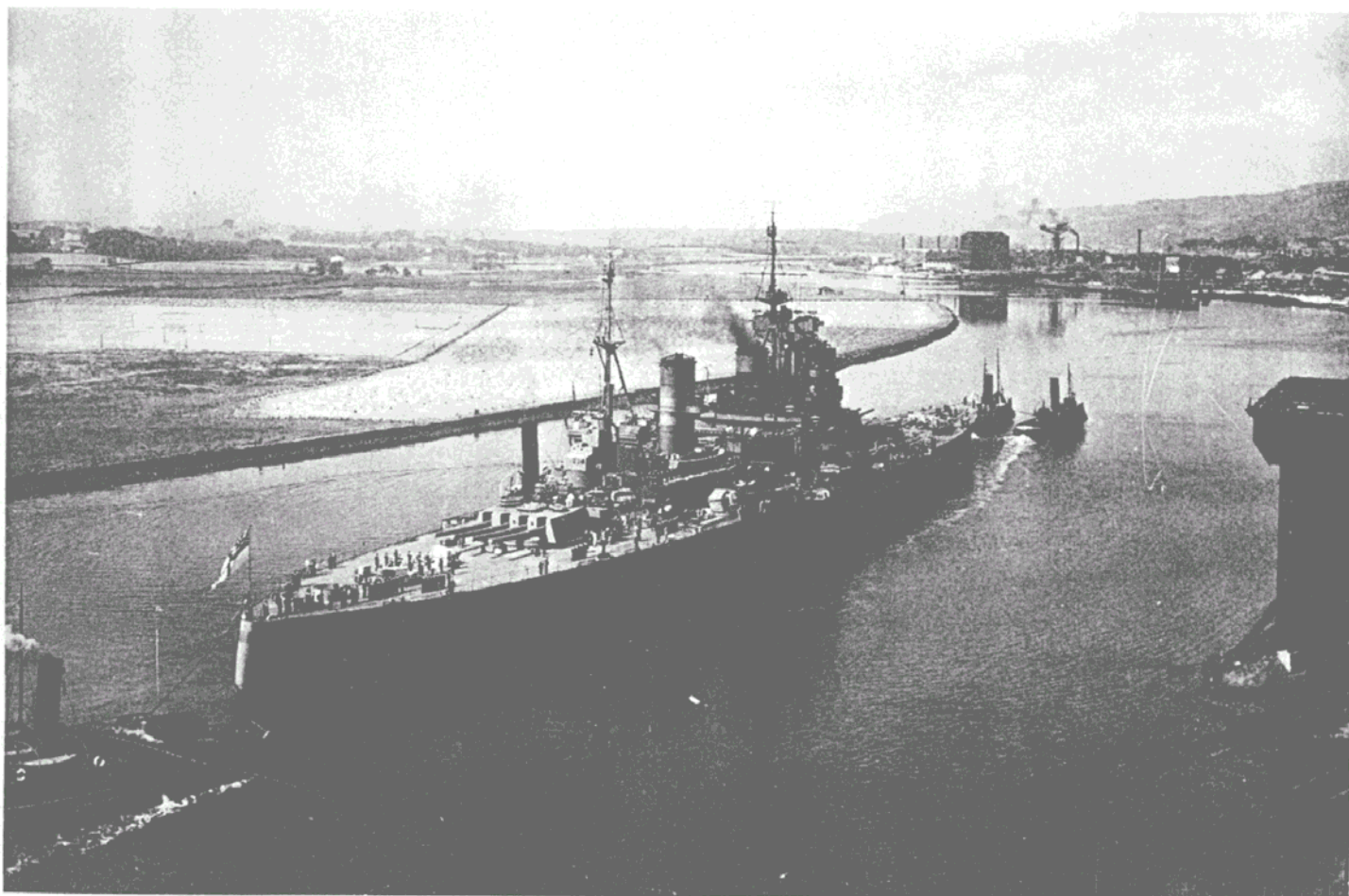


The Duke of York is shown during her construction at John Brown & Co., Clydebank. The large opening between bulkheads in the lower part of the photograph is for the magazine for "A" turret. The large ship under construction to the left is the RMS Queen Elizabeth. (Scottish National Archives)

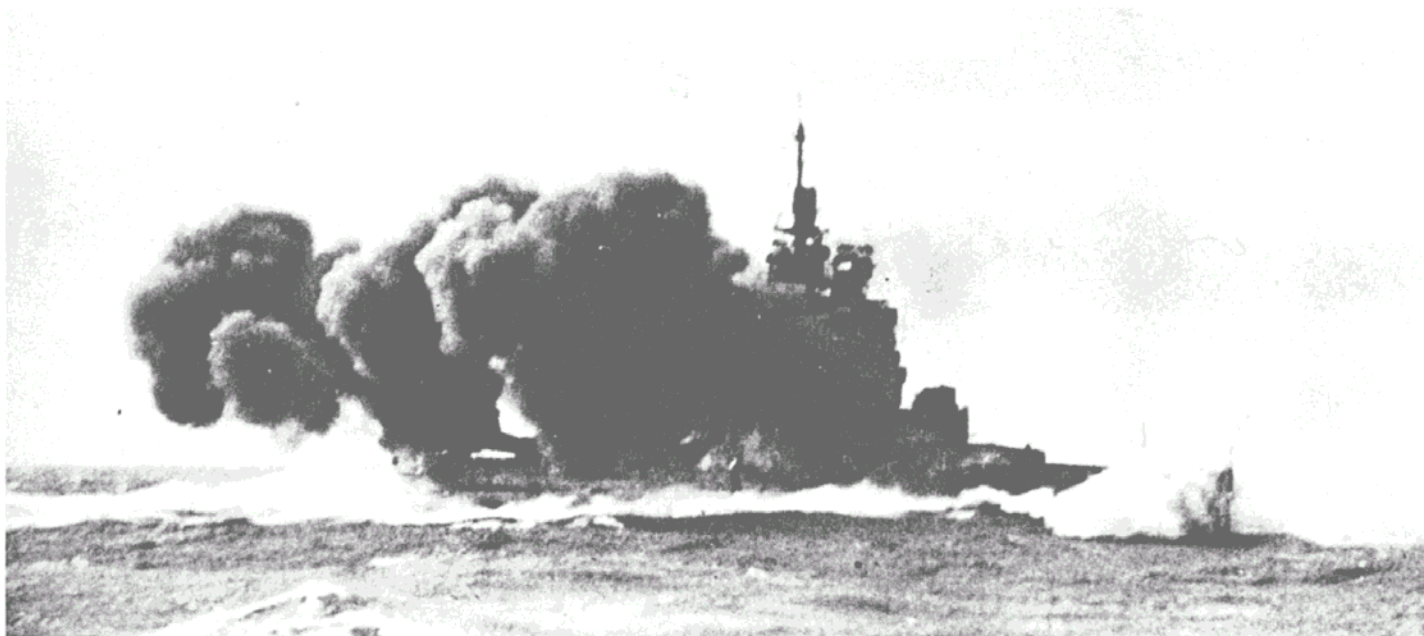


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The Duke of York is shown here shortly after her trials. Note the pom-pom battery on "B" turret, which replaced the U.P. projector. (Scottish National Archives)



The Duke of York is shown leaving the shipyard, newly completed and just commissioned. She is now completed and commissioned in the Royal Navy. (Scottish National Archives)



A total of 15,900 pounds of steel and high explosive is thrown into the air as the Duke of York fires a full ten-gun salvo from her 14-inch guns. (Royal Navy)



A view of the Duke of York in 1944. The five 20-mm machine-gun mounts on the fantail can be observed. Compare the wet bow of the battleship as compared with the light cruiser in the background. (British Information Services)

Action with the Scharnhorst. In 1943 the *Scharnhorst* moved to Norway and the convoys were more endangered. With the *Tirpitz* and two armored ships also in Norwegian fjords, it was necessary for the Royal Navy to provide heavy escorts for convoys to or from Russia. One of these was sighted by the Germans in early December 1943, and it was feared that the following convoy might be attacked by German surface ships. Two surface forces were assigned to provide distant cover to convoy JW 55B, which had left Loch Ewe on 22 December. On 25 December 1943, the *Scharnhorst* was reported at sea.

Force 1 (cruisers *Belfast*, *Norfolk*, and *Suffolk*, and four destroyers) made contact shortly after 0900 on 26 December. A brief engagement occurred around 0930, but the *Scharnhorst* outdistanced her pursuers, and again outran them after a brief skirmish around noon.



The Duke of York engaged the German battlecruiser *Scharnhorst* on 26 December 1943 in the Battle of the North Cape. The *Scharnhorst* was hit by at least ten 14-inch shells, while managing only a few near misses on the Duke of York. The damage from one of these near misses is shown here. An 11.1-inch shell splinter partially severed the port strut to the mainmast; this was the only damage sustained in the action by the British battleship. (Royal Navy, HMS Excellent)

Meanwhile, Force 2, including the *Duke of York*, the cruiser *Jamaica*, and four destroyers, was closing, and it was estimated that a night action with the *Scharnhorst* would commence around 1715. Then the *Scharnhorst* altered course, and contact was made at 1632, at 29,700 yards. Force 2 maneuvered for broadside fire. The *Belfast*, with Force 1, fired starshells at 1647 to illuminate the *Scharnhorst*. This failed, so the *Duke of York* fired a starshell from one of the other 5.25-inch guns, taking the *Scharnhorst* by surprise with her main battery trained fore and aft. By 1650 the *Duke of York* had closed to 12,000 yards and fired a full ten-gun broadside. Firing continued until 1824, and the *Scharnhorst* was seriously damaged by the fifty-two broadsides from the *Duke of York* and the gunfire of the accompanying cruisers. At 1655 a 14-inch shell had silenced turret Anton, while another struck at the waterline aft. Several seconds later a shell from the *Duke of York* exploded in number-1 boiler room. Despite this damage, the *Scharnhorst* regained speed and by 1824 had opened the range to 21,400 yards, when the *Duke of York* ceased fire after expending fifty-two broadsides.

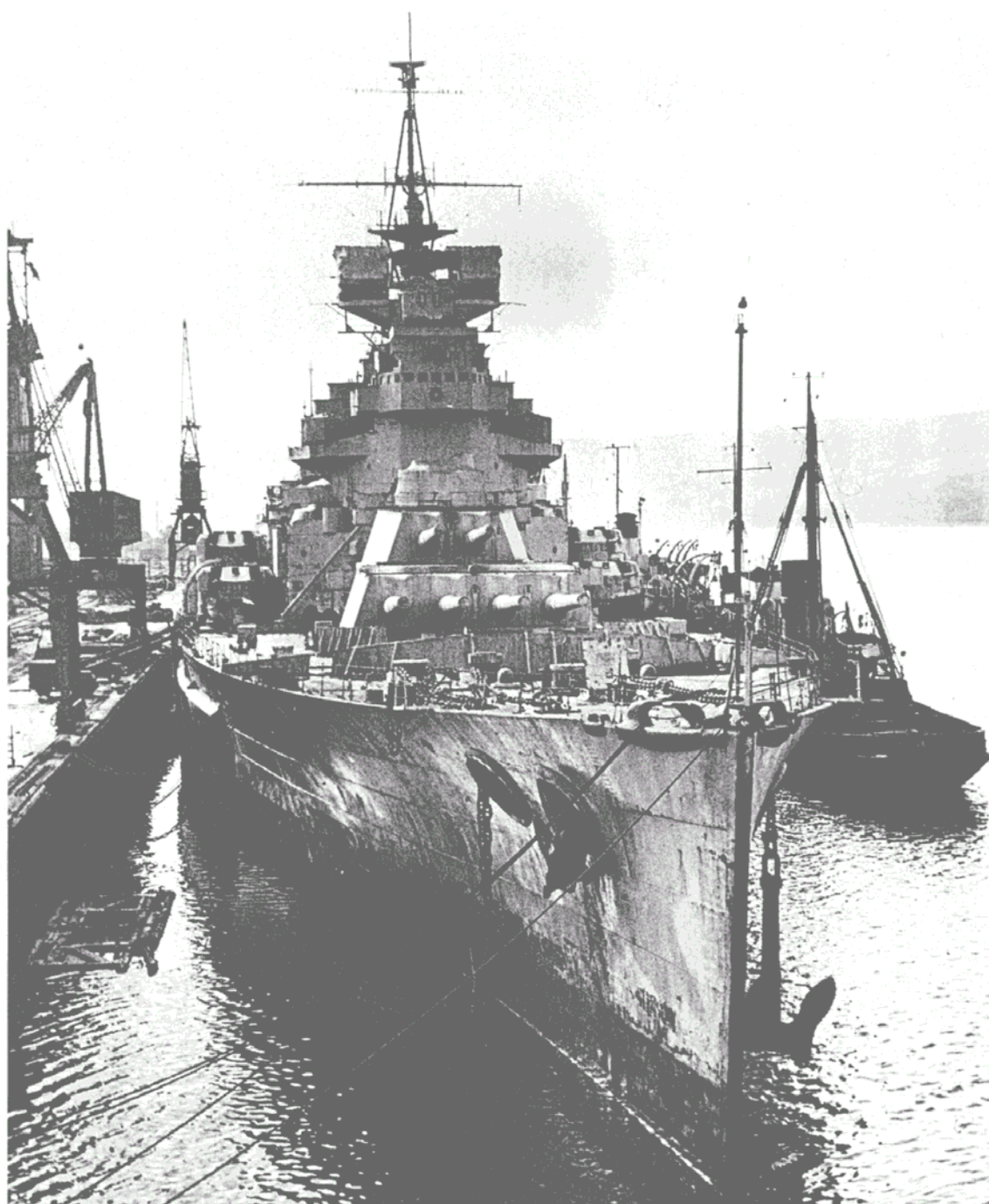
Shell damage. Although under heavy fire, the *Scharnhorst* straddled the *Duke of York* a number of times and made two very close near misses. Splinters from these near misses came aboard the British battleship and one partially severed one of the legs of the tripod mainmast. A 5.9-inch shell passed through the port strut of the foremast.

Destroyers then attacked with torpedoes and made three hits which slowed the *Scharnhorst* enough so that at 1901 the *Duke of York* again opened fire, at a range of 10,400 yards. She ceased fire at 1930 to allow the cruisers to close on the *Scharnhorst*. Ten 14-inch shells had hit the German battlecruiser, and these caused fires and explosions, knocked out turrets Anton and Bruno, and silenced almost all of the secondary battery. By 1916 all main turrets had ceased fire on the German battlecruiser, and her speed had been cut to ten knots. The *Duke of York* ceased fire at 1930.

Torpedo attacks by British cruisers and destroyers sealed the fate of the *Scharnhorst*, and she sank at 1940. The loss of life was exceptionally heavy aboard the German warship; only 36 men were saved while nearly 2,000 were lost.



The Duke of York is undocked late in 1944 after her modernization at Liverpool. New radar equipment and added antiaircraft guns helped prepare the ship for service with the British Pacific Fleet. (British Information Services)

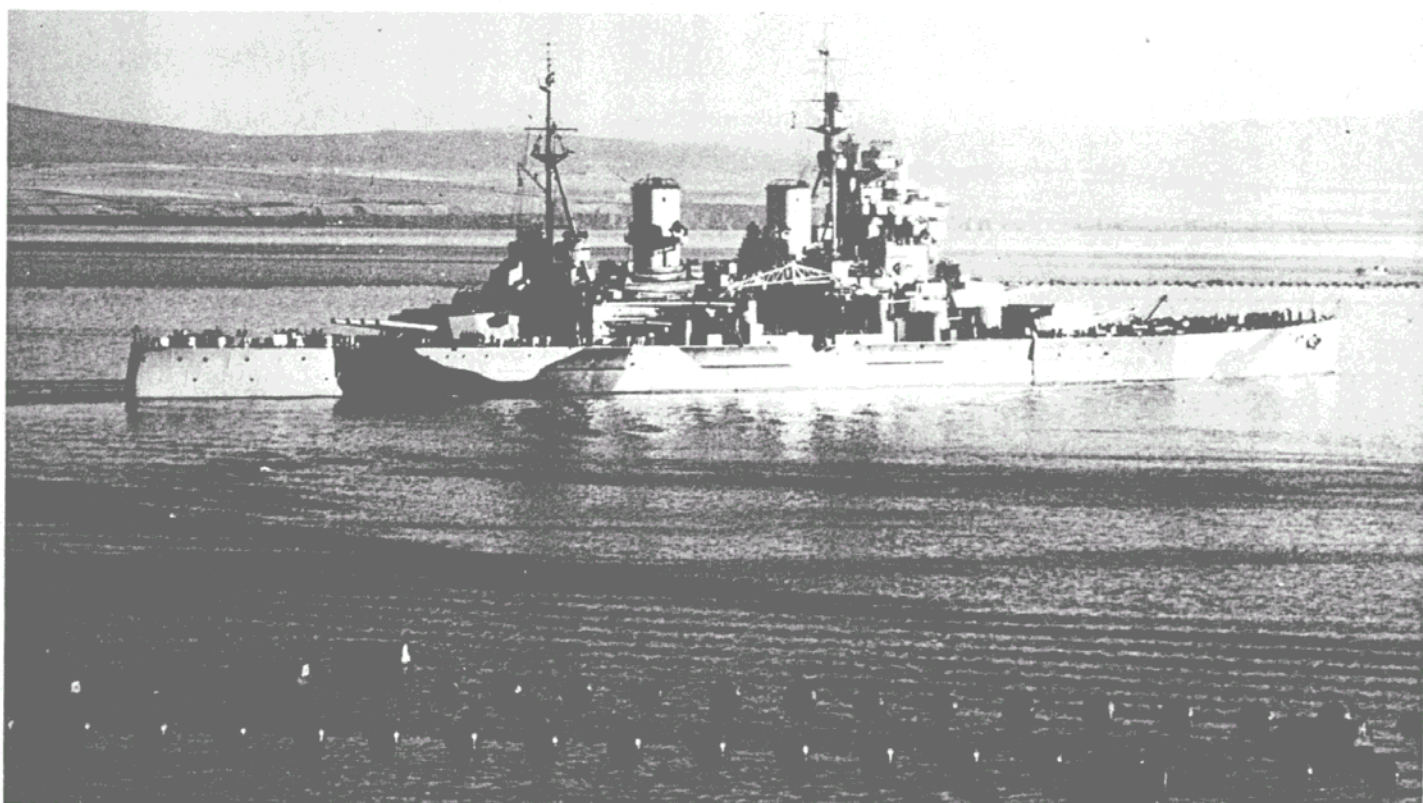


The Duke of York arrives at Faslane for scrapping on 1 March 1958. (I. L. Buxton)

Pacific operations. The *Duke of York* operated in the Arctic and as cover for carriers in air strikes on the *Tirpitz* until September, then was overhauled and partially modernized at Liverpool. Radar equipment and additional antiaircraft guns were added. She was then ordered to the British Pacific Fleet and sailed in company with the *Anson* in April of 1945. She was the flagship of the British Pacific Fleet when the Japanese surrendered, and remained so until June 1946, when she returned to Plymouth for overhaul. As flagship of the Home Fleet, she remained in service until April 1949, then became flagship of the Reserve Fleet, in reserve, until September 1951.

Final Disposition. The *Duke of York* was laid up in November 1951, and on 18 May 1957 she was ordered scrapped. She was broken up by Shipbreaking Industries, Ltd., in Faslane.

Anson—Operational History. The keel of the *Anson* was laid at the Swan Hunter and Wigham Richardson Shipyard on 20 July 1937. The propulsion machinery was constructed by the Wallsend Slipway Company. The ship was launched on 24 February 1940 and was completed on 22 June 1942. Completion was



The Anson, fourth ship of the class, is shown at anchor at Scapa Flow on 9 March 1943. The ship is protected by a double row of antitorpedo nets around her anchorage.



The Anson, foreground, with ships of the Reserve Fleet in Gareloch on 15 July 1956. The light cruiser Swiftsure is on her port beam, with the King George V on her port bow. (I. L. Buxton)



The Anson being broken up at Faslane on 17 November 1958. The remains of "A" turret can be seen in the foreground. The King George V is shown forward of the Anson. (I. L. Buxton)

delayed largely because of the inclusion of fire-control radar, additional antiaircraft weapons, and small changes to subdivision and outfit indicated in the survey of the loss of the *Prince of Wales*.

Much of her World War II service was spent in Arctic operations. From September 1942 to June 1944 she covered convoys to and from North Russia, was part of a covering force for an aircraft carrier task force that attacked the *Tirpitz* on 3 April 1944, and she, herself, later attacked enemy shipping off Norway. In June 1944 the *Anson* began an extensive overhaul at Plymouth; this made her the most modern of her class. On 25 April 1945, with the *Duke of York*, she sailed to join the British Pacific Fleet, and so served until 28 June 1946, when she returned home to become a training ship and later flagship of the Training Squadron. In 1949 she carried Princess Elizabeth and the Duke of Edinburgh to the Channel Islands for an unofficial visit.

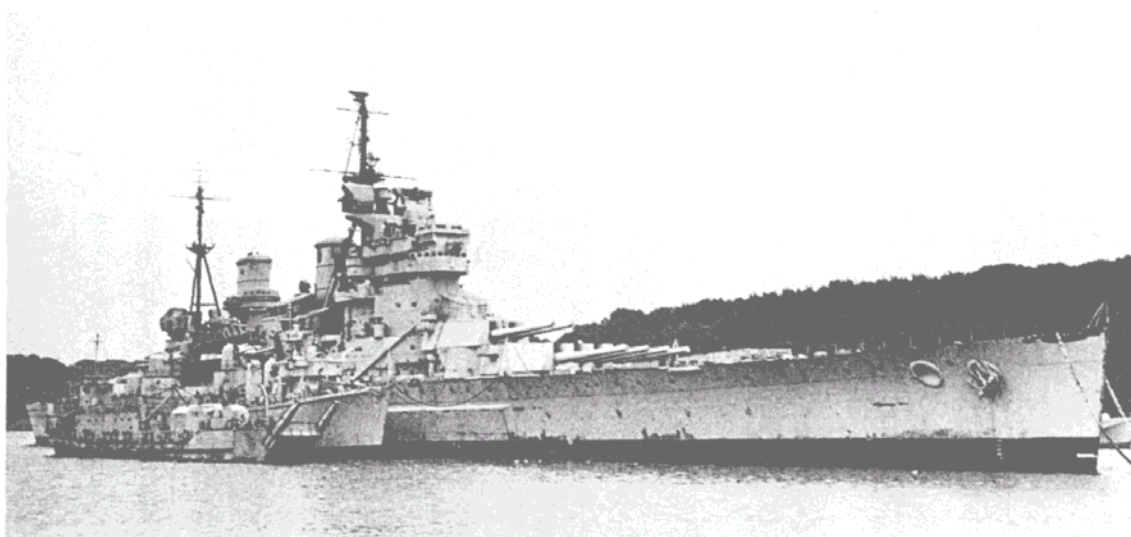
Final Disposition. In November 1949 the *Anson* was placed in reserve, and in 1951 she was towed to Gareloch. On 17 December 1957 she was purchased for scrap by Shipbreaking Industries, Ltd., Faslane.

Howe—Operational History. The keel of the *Howe*, last ship of the class, was laid on 1 June 1937 at the Fairfield Shipyard in Govan. The ship was launched on 9 April 1940 and completed 20 August 1942. The *Howe* benefited from the years of experience in World War II. She carried improved antiaircraft armament and radar equipment. Aircraft handling facilities were removed, although the catapults remained.

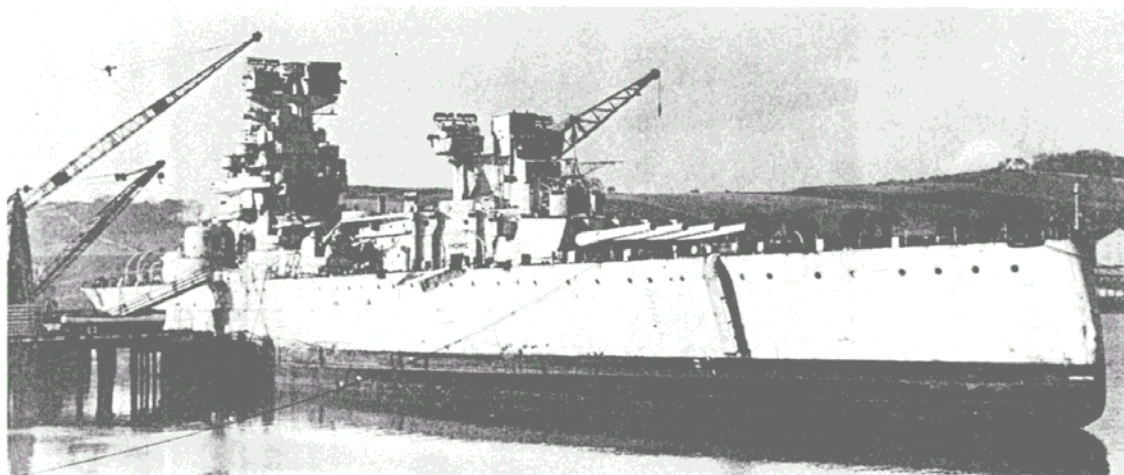
After commissioning, the *Howe* was attached to the Home Fleet from December 1942 through May 1943, guarding convoys to Russia. She then sailed to Gibraltar for the invasion of Sicily in July, and took part in the September 1943 surrender of the Italian fleet. Later the same month she returned to Great Britain for convoy duty. At the end of 1943 she underwent a long overhaul at Devonport, where a number of alterations were made. Her antiaircraft armament was increased, changes were made to her radar, and her watertight integrity in the stern was improved. Modifications were accomplished in the officers' and crew quarters for operations in tropical climates. (These included changes in insulation and the extensive use of air-conditioning equipment.)



The enclosed secondary conning station on the after funnel was a distinctive feature of the Howe. (Imperial War Museum)

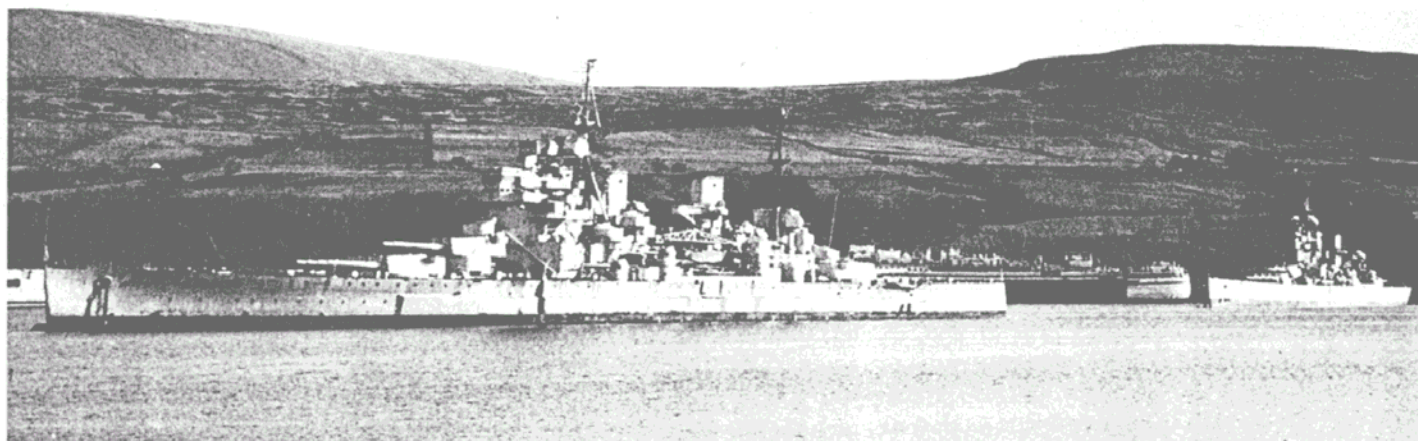


The Howe in reserve at Devonport, 5 August 1957. (I. L. Buxton)



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The Howe is shown undergoing scrapping at Wards, Inverkeithing on 5 November 1958. (I. L. Buxton)



With the close of the battleship era, the more modern ships were placed in reserve, while the older ships were scrapped. Here are two units of the class at Gareloch on 23 November 1957. The Duke of York is in the foreground and the King George V astern of her. (I. L. Buxton)

Pacific operations. In August 1944 the *Howe* joined the Far Eastern Fleet at Trincomalee, Ceylon, where in November, Admiral Fraser hoisted his flag as commander in chief of the British Pacific Fleet. She then steamed to Sydney, Australia, where the fleet assembled.

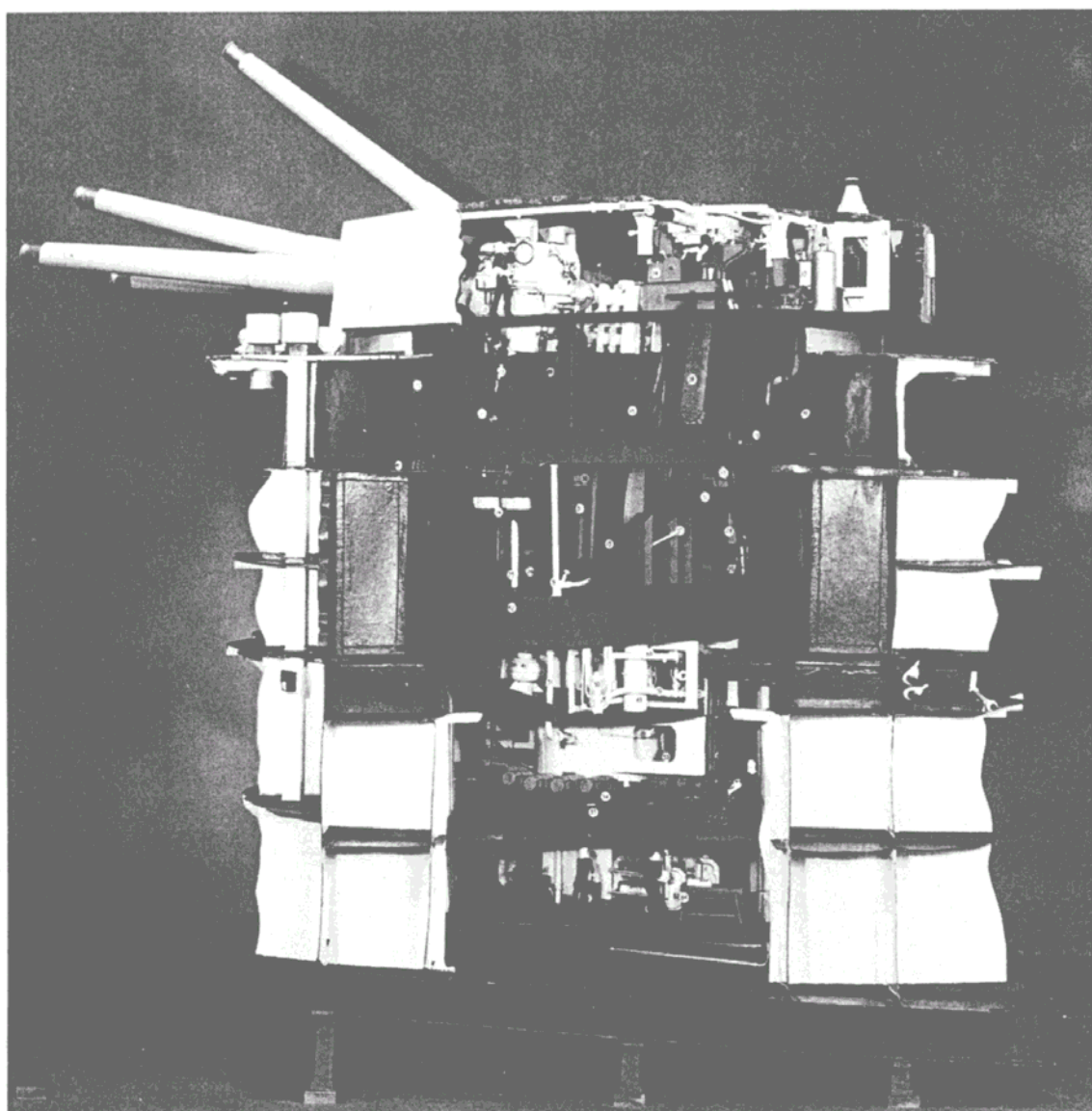
Between March and May 1945 she was part of Task Force 57 and took part in the bombardment of Miyoko on 4 May. Five days later her antiaircraft battery brought down an attacking kamikaze. The *Howe* underwent an overhaul at Durban from June to September 1945, and in January 1946, after stays in Mombasa and Singapore, she returned to Great Britain. Later that year, she joined the Training Squadron at Portland.

Final Disposition. In 1951 the *Howe* was placed in reserve and towed to Devonport. She was ordered to be scrapped in 1957. On 27 May 1958, the *Howe* was towed to Inverkeithing to be broken up by T. W. Ward and Co. The Royal Navy presented the ship's bell to St. Giles Cathedral in Edinburgh.

Armament.

Gun characteristics for these ships are shown in Table 5-6.

Main battery. The division of the main armament was predicated on the desire for the largest possible salvo and the need to distribute salvo fire forward and aft for maximum effect. Weight-saving features of the *Nelson*-style battery—three main-battery turrets forward—were studied in an effort to shorten the armor box and eliminate the disruptive effects of a main-battery turret in way of the shafting, but they were discarded as forcing the propulsion plant too far aft. Furthermore, it was believed that the blast effects from a twelve-gun salvo of 14-inch guns would have been as devastating on adjacent structure as those of nine 16-inch guns, which were observed during gunnery trials of the *Nelson*. During the 1931 sea trials of the *Rodney*, considerable blast damage was also sustained in the main conning station when a full



This is a view of a model of the 14-inch (Mark III) quadruple turret of the King George V Class. The guns were mounted in separate sleeves and could be elevated and fired independently of one another. (Imperial War Museum)

TABLE 5-6

Gun Characteristics

Gun	14"/45 caliber (356 mm)	5.25"/50 caliber (134 mm)	
Shell weight (lb)	1,590 (721 kgs)	80 (36.3 kgs)	
Muzzle velocity (fps)	2,400 (732 m/s)	2,600 (792 m/s)	
Maximum range (yds)	36,300 (33,193 m)	23,400 (21,397 m)	
Maximum elevation (degrees)	40	70	
Gun	"2-pounder"*	1.57"/56 (40 mm)†	0.79"/70 (20 mm)
Shell weight (lbs)	1.81 (0.82 kgs)	1.98 (0.898 kgs)	0.27 (0.122 kg)
Muzzle velocity (fps)	2,300 (701 m/s)	2,890 (881 m/s)	2,770 (844 m/s)
Maximum range (yds)	5,000 (4,572 m)	11,000 (10,058 m)	4,800 (4,389 m)
Maximum elevation (degrees)	80	90	90

* 1.594"/40 (40.5 mm)

† Fuze self-destructive at 5,000 yards (4,572 m).

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nine-gun salvo was fired abeam. Gunfire over the bows was similarly damaging. Broadships were tolerable only when fired well abeam. Fast battleships were deemed to require main-battery coverage in all sectors, which meant abandoning the turret-forward arrangement.

The decision to mount 14-inch guns was made despite the fact that other European powers favored larger calibers. The United Kingdom felt treaty-bound to retain the 14-inch guns until 1 April 1937, and wanted to commence the construction of two battleships by January. If other navies adopted heavier calibers, this challenge would be met by the *Lion*-class ships of the 1938 program, which could be completed by 1942 or 1943. Another factor against the larger caliber was the serious shortage of skilled technicians and ordnance designers following the completion of the *Nelson* and *Rodney* in 1927. There also were compelling pressures to reduce weight. The smaller caliber was accepted, even though older Royal Navy ships mounted 15-inch and 16-inch guns. The better rate of fire proposed for the new 14-inch turrets, despite the relatively small reduction in destructive power, when considered in conjunction with new and improved design of loading arrangements, was believed to represent a net step forward. These guns were of all-steel radial-expansion construction, which permitted a lighter gun with less likelihood of barrel droop, and which would have more accurate fire and be capable of longer barrel life.

There was much debate over the choice of gun caliber. Winston Churchill, former First Lord of the Admiralty and then a member of Parliament, was a severe critic of the 14-inch armament. In a letter, dated 1 August 1936, he wrote:

Nothing would induce me to succumb to 14-inch if I were in your shoes. The Admiralty will look rather silly if they are committed to two 14-inch-gun ships, and both Japan and the United States go in for 16-inch a few months later. I should have thought it was quite possible to lie back and save six months in construction. It is terrible deliberately to build British battleships costing 7,000,000 £ apiece that are not the strongest in the world! As old Fisher used to say, "The British Navy always travels first class."

The Mark VII 14-inch guns were mounted in one Mark II twin turret forward and two Mark III quadruple turrets, one forward and one aft. The guns could be elevated 40 degrees and depressed 3 degrees. Training arcs were: turret "A", 286 degrees; turret "B", 270 degrees; turret "Y", 270 degrees. Training and elevating was done through hydraulic drive, with rates of two and eight degrees per second, respectively. A full-gun broadside weighed 15,950 pounds, and a salvo could be fired every 40 seconds. The quadruple turrets weighed 1,582 tons, the twin turret 915 tons.

The turrets were designed by the Vickers Armstrongs Elswick Works, but sets of each type of equipment were manufactured by Vickers Armstrongs in Barrow. Difficulties in the hydraulic elevating and training gears were eliminated before the *King George V* and *Prince of Wales* went into action. A considerable amount of design effort was expended to make the turrets as flashtight as possible. This complicated the mechanical design of the turrets, particularly the quadruple mountings. Due to insufficient clearances and slightly distorted link mechanisms, failures in the intricate safety interlocks in the loading sequence for antirash precautions caused jams during drills and practice firings of the *King George V*. Clearances were increased, but in the battle with the *Bismarck*, jams occurred in other parts of the mechanism. The *Prince of Wales* had similar jams in her action with the *Bismarck*, but Vickers Armstrongs technicians assisted the crew in repairing them. Major difficulties with the complicated system of interlocks resulted in disabling casualties before the system was made safe and reasonably reliable.

The 14-inch guns could be fired from two main-battery directors, by "B" turret or by local control. A main armament control tower was placed forward and an armored secondary conn aft. "B" turret was fitted with a 30-foot duplex rangefinder, while "A" and "Y" turret had long-base single rangefinders. The director control towers were to be equipped with 15-foot base rangefinders, which were actually fitted to the *King George V* and *Prince of Wales*. It was subsequently decided to use 22-foot rangefinders in the forward director control towers of the *Duke of York*, *Anson*, and *Howe*.

Secondary battery. The secondary armament aroused much discussion among naval constructors and ordnance designers. The change to the new 5.25-inch/50-caliber dual-purpose gun, Mark 1, marked a new era in which defense against air attack became more important than defense against surface attack, at a time when light cruisers and destroyers were in many instances approaching heavy cruiser standards in displacement and gun caliber. Medium-caliber guns such as the 6-inch mounts in the *Nelson* and *Rodney* were no longer acceptable because their slow rate of fire decreased their antiaircraft capability.

During the redesign of the *Queen Elizabeth* and *Valiant*, it was firmly established that secondary guns not useful against both air and surface targets had no place aboard a battleship in 1933-34. At first, 4.5-inch dual-purpose guns of the type mounted on the reconstructed *Queen Elizabeth* were favored for Britain's new battleships, but they were thought to be less effective than the 5.25-inch guns against destroyers and light cruisers. The 5.25-inch guns were the largest dual-purpose guns believed capable of firing fast enough to damage ships as large as light cruisers. The 5.25-inch shell had an explosive charge heavy enough to damage a destroyer or light cruiser and yet was reasonably light enough to be handled by a gun crew. For air defense, a mechanical time fuze was developed, and the large explosive charge resulted in a rather powerful and effective antiaircraft shell.

Sixteen of these guns in eight twin mounts, weighing about 81 tons each, were grouped at four corners of the citadel, with a twin mount on the main deck and another superimposed above it nearer amidships. This disposition gave better arcs of fire, freedom from blast, more separation of the magazines, and a better arrangement of the ammunition supply. The cupolas for these mounts revolved on either the upper or superstructure deck; between-deck mountings traveled on roller paths on the armored deck. This permitted flat-trajectory or high-angle fire. Loading was semiautomatic, nominal rate of fire was ten to twelve rounds per minute, maximum range was 23,400 yards at a 45-degree elevation, and the antiaircraft ceiling was 49,000 feet. The guns could be elevated to a maximum of 70 degrees and depressed a maximum of 5 degrees. However, these guns were only able to fire seven-eight rounds per

minute per gun in service, due to the heavy weight of the shell and the fact that the 5.25-inch round was semifixed, requiring much crew handling until it was rammed into the breech.

Antiaircraft battery. Concern over high-level bombing concentrated interest on large-caliber antiaircraft weapons, with an almost total neglect of close-range weapons. The adoption of four two-pounder octuple pom-pom mounts was the result of specifications drafted before the aircraft menace was appreciated. This situation was not unique in the Royal Navy; such inadequacies existed on battleships of other countries before World War II. However, the Fleet Air Arm lacked aircraft comparable to Japanese or American types, and the serious threat of high-speed, low-level aerial torpedo attack was not anticipated by the Royal Navy antiaircraft ordnance designers.

To augment the original antiaircraft battery, there were four 0.5-inch quadruple machine-gun mounts, but in 1939 these were replaced by two Mark VI pom-pom mounts. In 1940, to combat air attack, four unrotated projectors (UP) mountings were fitted, one on "B" turret, two on "Y" turret, and one replaced a pom-pom mount added in 1939 at the stern on the *King George V*. The *Prince of Wales* had only three projectors, with a single mount on "Y" turret. This weapon used a 3-inch rocket to fire a 7-inch aerial mine to a height of 1,000 feet, where it exploded and released a parachute that let the mine down on a wire. If a plane hit the wire, the mine would be pulled against it and explode. Each mount had twenty smooth-bore barrels. Salvos of ten barrels were fired by cordite charges. The weapon was never used by either the *King George V* or the *Prince of Wales* in action, and was later replaced by two Mark VI pom-poms because of the danger of fire in exposed ready-service lockers, as demonstrated in the *Hood's* engagement with the *Bismarck* and *Prince Eugen*.

Evaluation of the air attacks on the *Illustrious* in Malta during May 1941 showed that all capital ships needed reinforced light antiaircraft defense against new aircraft. Before the *Prince of Wales* sailed for Singapore, she was given two additional octuple two-pounder mounts, eight single 20-mm Oerlikons, and a single 40-mm Bofors mount. Japanese air attacks on the *Prince of Wales* and the *Repulse* showed the urgent need for more effective short-range weapons.

A board of inquiry reviewed the loss of the *Prince of Wales*, and its recommendations concerning light antiaircraft armament were quickly adopted in the four sister ships then building or in service. Improved short-range air defense against air attack was considered extremely important. Battleships of the *King George V* class still under construction received increased close-range armament, and the already completed *King George V* and *Duke of York* had their armament progressively increased. Major changes in the light antiaircraft weapons for this class are summarized in the data tabulation.

The pom-poms mounted in these ships were designed and produced by Vickers Armstrongs as the result of a post-World War I requirement for a multiple mounting effective against close-range bombers or torpedo planes. The first model, tested in 1927, was superior to anything developed abroad, and in 1935 was still considered an excellent weapon. They had a 1.594-inch bore and usually had a barrel length of 40 calibers. They fired a 1.8-pound shell at the rate of 96-98 per minute for controlled fire and 115 rounds per minute for automatic fire. Range was only 5,000 yards, as a result of the low velocity of 2,300 feet per second. The Mark VI octuple mount weighed 16 tons. The Mark VII quadruple mount weighed 10.8 tons if power-operated; it could be elevated to 80 degrees and depressed to 10 degrees at the rate of 25 degrees per second, which was also the rate of train. Normal ammunition supply was 1,800 rounds per barrel. Unfortunately, the pom-pom lacked a satisfactory shell and had insufficient range to destroy Japanese torpedo planes before they reached their release points.

Torpedo tubes. Although a torpedo armament was considered for the *King George V* class in the original characteristics and the *Nelson* and *Rodney* carried it, the weight and space limitations of the 35,000-ton displacement excluded such an armament in the final ship design.

Aircraft. Originally, four spotting aircraft were to be carried, as fire-control radar had not been developed and the aircraft were expected to increase the search area. Two planes were deleted in 1938 and the remaining two in 1942. The catapult was removed from some ships in 1943–45 refits to make space available for boat stowage. The area originally used for boat stowage was used for additional antiaircraft weapons. In 1944 and 1945, the hangars were adapted for crew accommodations.

Protection. Designing the protective armor for these ships was a difficult task, as it had to be the heaviest that was practical within the 35,000-ton limit. British design philosophy required incorporation of the latest improvements in ship structure and protection and the ability to sail to, and operate in, any part of the world for long periods. This demanded sufficient endurance, plus protective features enabling these ships to absorb a reasonable amount of punishment with undiminished battle effectiveness.

Protection accounted for 34 percent of the standard displacement in this class, usual British battleship design practice. In comparison with the *Hood*, armor weight as a proportion of the overall weight was 2 percent less, but the *Hood* had greater splinter protection over her entire length, while the *King George V* had more concentrated protection in her armored citadel.

The armor thicknesses and underwater side protection scheme evolved from tests completed prior to design work. Reexamination of tests on the German battleship *Baden* and the old British dreadnoughts *Superb*, *Monarch*, and *Empress of India* led to the conclusion that side armor protection should extend as far below the standard-load waterline as practical. The post-World War I test bombing of the German *Ostfriesland* by the United States was evaluated, leading to further British tests on the old battleship *Marlborough* in 1931. These tests, in connection with the reconstruction of the *Warspite*, indicated that 5- or 6-inch deck armor would repel any bombs then existing. The underwater side protection system was determined from experiments on Job-74—a full-scale mockup, 100-foot section of the *King George V*. It was finally agreed that armor should resist a 15-inch armor-piercing shell, and the underwater defense system should withstand a 1,000-pound TNT charge.

The matter of protective features was eventually studied by the Board of the Admiralty, which concurred with the opinions of Sir Arthur Johns, Director of Naval Construction, in favoring side armor arranged vertically in a plane parallel to the armored torpedo bulkhead. Consequently, the *Nelson* system of waterline subdivision and outboard sloping armor was abandoned. Fears that a shell might pass below such a system when a ship rolled or pitched were based on tests of the *Nelson* system, when fragments of a shell that was exploded against the sloping 13.75-inch belt were deflected downwards against the torpedo bulkhead; if a shell by-passed the armor it might penetrate the torpedo bulkhead. The sides at the extremities were unprotected, and the side belt was not carried beyond the citadel.

Although these ships were armed with a new model 14-inch gun, the rush to commence the construction of the first two ships by 1 January 1937 necessitated the use of the 15-inch guns of the *Queen Elizabeth* class as the design model for the armor protection. Gun trials of the new 14-inch guns had not been completed by the end of

1935, but it was known that France, Germany, and Italy were developing 15-inch guns for their new battleships. Nevertheless, the design for the 14-inch guns continued, and 1936 trials of the new 14-inch guns showed that the proposed armor thicknesses in the citadel would have to increase. Preliminary data from the Job-74 experiment indicated that deeper underwater protection was necessary to withstand attack by 1,000-pound torpedo charges. Faced with these necessary changes, it was reluctantly decided to change "B" from a quadruple to twin turret; this saved some 770 tons in weight which was applied to the upgrading of the armor and underwater protection.

The revised armor thicknesses provided an immunity zone of 17,200 to 32,000 yards against the 15-inch gun firing a 1,938-pound armor-piercing shell. Against the 16-inch guns of the *Nelson* and *Rodney*, which fired 2,048-pound armor-piercing projectiles, the side belt could be penetrated at 16,500 yards and the 5.88-inch decks at 33,250 yards. Against the much more powerful U.S. 16-inch/45-caliber gun with a 2,240-pound armor-piercing shell, the machinery spaces would have been immune from 25,000 to 28,000 yards; the magazines below armor decks from 23,000 to 31,000 yards; the barbettes of the main turrets above the armor deck from 27,000 yards.

The deck protection was effective against 1,000-pound armor-piercing bombs dropped from 12,000 feet or a 2,000-pound bomb dropped from 3,500 feet. Armor, 4.90 inches thick, was determined to be sufficient protection against such bombs.

The vertical main side belt of cemented armor, 415 feet long and 23 feet deep (56 percent of the waterline length), was 14.71 inches thick at the main magazines and 13.75 inches thick outside of the propulsion plant. It tapered to 5.38 inches outside the former and 4.42 inches outside the latter, at a distance of 8.25 feet below the standard waterline. Armor extending 12 feet below the design waterline, an important feature, comprised the greatest amount ever so used in a British battleship. The lower side belt extended 40 feet forward and 37 feet abaft the citadel, comprising underwater protection for a total of 492 feet.

The metallurgical composition of the face-hardened side armor was described by J. D. Scott in *Vickers—A History*:

The design . . . called for very heavy side armor and barbettes, and Beardmore's, Firth-Brown, and the English Steel Corporation were called in on a development program. The samples submitted by the English Steel Corporation were originally given a 20 to 25 percent hardfaced depth, but in the course of development this was increased to 30 percent and, in a very few cases, as much as 33 percent. At the same time the carbon content was lowered to produce a case which was more tough but slightly less hard than given by the original composition. The importance of this thicker "face" was that it broke up shells which were traveling fast enough to penetrate it, so that while the armor might be penetrated, the shell which had done the job was no longer, to use the armor makers' expression, "fit to burst." The prevention of internal explosions in the ship was considered . . . preferable, usually, to watertight integrity.

The side armor was of excellent quality, providing resistance equal to that of U.S. class "A" armor of 25 percent greater thickness.

Deck armor. Growing awareness of air attack and concern over the effect of long-range armor-piercing shells resulted in a main deck of noncemented armor 5.88 inches thick over the magazines, capable of resisting a 16-inch 2,375-pound shell (projected gun for the *Lion* class) at a range of 30,625 yards. Propulsion plant protection, reduced one inch in thickness, could resist the same shell at 27,250 yards. There were no other armor decks in the armored citadel. Horizontal armor was extended to the bow and stern on the lower deck. Uptakes and air intakes in the armor deck were protected by armored gratings and 1.96-inch armor plate on the sides within the superstructure.

The lower armor deck from the forward armored bulkhead to the collision bulkhead ranged in thickness from 2.46 to 4.90 inches. Aft, it extended from the after armored bulkhead to just beyond the steering-gear room, decreasing in thickness from 4.90 to 4.42 inches. This deck was intended to prevent damage from extending above or below the standard waterline; in the vicinity of the steering engine room the outboard extremity was sharply knuckled, and the deck inclined 30 degrees from the horizontal as additional protection against bomb or shell hits. This weight-saving expedient eliminated the necessity of extending vertical armor past the armored bulkhead to protect shafts and steering gear.

Conning tower. Conning tower armor, greatly reduced in thickness in comparison to previous battleships, was incorporated into the bridge structure. A comparison of conning tower armor protection with that of past British battleships is in Table 5-7.

TABLE 5-7

Conning Tower Armor Protection

Ship	Sides	Roof	Deck
1921 Battleship (proposed)	14.71" (373 mm)	7.85" (199 mm)	5.88" (149 mm)
1921 Battlecruiser (proposed)	11.76" (298 mm)	5.88" (149 mm)	
<i>Hood</i>	10.80/8.84" (275/205 mm)	4.90" (124 mm)	2.94" (75 mm)
<i>Queen Elizabeth</i> (1912)	10.80" (275 mm)	2.94" (75 mm)	2.94" (75 mm)
<i>Royal Sovereign</i> (1913)	10.80" (275 mm)	2.94" (75 mm)	2.94" (75 mm)
<i>Nelson</i>	13.73" (348 mm)	6.38" (168 mm)	3.92" (100 mm)
<i>King George V</i>	3.94" (100 mm)	1.47" (38 mm)	1.47" (38 mm)

The trend toward lighter conning tower armor, in which weight reduction was a paramount consideration, began with the post-*Nelson* battleship studies and continued in the reconstruction of the *Valiant*, *Warspite*, and *Queen Elizabeth*. Experience in the Battle of Jutland was also a factor; due to the small target area and small chance of being hit, heavy protection for the conning tower was considered an unnecessary luxury.

Additional weight involved with the heavier deck protection and armament in the reconstructed battleships was compensated for by lighter machinery and the removal of the heavy conning tower and casemate armor. The removal of the conning tower provided the space for a large bridge, director control towers, hangars, and an athwartship catapult. All these considerations influenced the design of the *King George V* class and later battleships.

The communications tube to the conning tower, and access shafts to the main directors, had only one-inch armor. Reduced thicknesses in these areas permitted more armor elsewhere. The secondary conn position on the after funnel had armor protection less than one-inch thick.

Armored bulkheads. Three transverse armored bulkheads were thinner than those in the *Nelson* and *Rodney*. The main armored bulkheads were heavily armored over two decks where the 14-inch magazines were unprotected by the main armor deck: thickness varied from 9.80 inches at the centerline to 11.76 inches over the outboard strake where a shell hit was most probable. Beneath the lower armor deck, which provided some protection for "A" and "Y" magazines, 1.96-inch-thick plate extended to the level of the inner bottom. This deck terminated abaft the steering engine room where, with some protection necessary against projectiles, a small 3.92-inch-thick bulkhead extended down from the deck to the shell.

Turret armor. Turret armor protection was not as thick as past British battleships except for the roof, where horizontal protection was emphasized. Nevertheless, the armor plate used in these ships was to be of greater resistance to penetration than armor used in the *Nelson* class.

Barbette protection was not as severely graded as in previous ships. The greatest thickness of 12.75 inches was used on the beam where shell hits were most likely; near the centerline it thinned to 11.76 inches. Between the armored decks, where side protection was provided, 1.96-inch thick noncemented armor was used.

An armor thickness of 1.47-inch was regarded as necessary protection against shell or bomb fragments, but in the secondary mounts, protection was limited to 0.98 inches; stability requirements demanded careful control of weights high in the ship, and extensive splinter protection for such mounts would have produced a weight increase which was intolerable. Nonetheless, when these ships were first designed, the bulkheads surrounding the 5.25-inch magazines were of ordinary steel. The Board was rather disturbed about this in that during a night engagement, where ranges between ships probably would be shorter, a shell could pass through the torpedo bulkhead, and the splinters from such a hit could reach these magazines. It was decided to place some additional plating at the sides of the 5.25-inch magazines and on the deck over. This change was made during construction.

The bridge, the gunnery control spaces, and other positions continually manned had splinter protection. The after 14-inch director was protected by 2.94-inch noncemented armor (Class B) and the roller-path structure was a circular bulkhead 12 feet in diameter formed from 1.96-inch armor plate. Cable trunks and junction boxes to both directors were protected by 1.47-inch armor. The forward 14-inch director was constructed of 0.50-inch high-strength (D quality) steel; its circular support was 0.75-inch plate. Additional protection for the director was considered, but not approved by the Admiralty, in 1940.

Side protection. Underwater side protection was based on tests with Job-74, previously mentioned. The conclusion drawn from these experiments was that the "sandwich bulge" concept would be very effective in resisting a 1,000-pound charge. With the beam limited by dockyard clearances, this scheme provided some means of absorbing the explosive energy other than an excessively deep system which would complicate the machinery arrangement.

The thick torpedo bulkhead was moved inboard as far as the volumetric requirements of the propulsion plant permitted, and localized protection—void spaces or nonvital compartments—was provided inboard of the bulkhead in certain areas. Torpedo tests on Job-74 showed that leaks were possible in riveted connections in the holding bulkhead—hence, the need for a fourth void compartment wherever possible.

The side protection system was subdivided longitudinally into three watertight compartments outboard of the holding bulkhead, with the central space liquid-loaded. Because this system could produce large lists after battle damage, a rapid flooding system working through a seacock served several adjoining compartments. Salvage pumps handled heavy flooding; firemain and portable pumps cleared minor leaks or residue water. A saltwater displacement system in the wing tanks kept the central layer of the system liquid-loaded at all times, making possible a reduced depth for the side protection system as compared to the *Hood* or *Nelson*. Despite such means to satisfy damage-control requirements for quick counterflooding, the loss of the *Prince of Wales* indicated a need for a deeper system and an emergency power supply to electric pumps.

The major dimensions of the torpedo defense system are tabulated in Table 5-8.

TABLE 5-8

Characteristics of Side Protection System

<i>Location</i>	<i>Depth at ½ Draft</i>	<i>Total Bulkhead Thickness</i>	<i>Torpedo Bulkhead Thickness*</i>
"A" turret	10.00' (3.05 m)	2.50" (63.5 mm)	0.875" (22 mm)
"B" turret	13.25' (4.04 m)	2.50" (63.5 mm)	0.875" (22 mm)
Amidships	13.00' (3.96 m)	2.25" (57.2 mm)	0.750" (19 mm)
"Y" turret	13.50' (4.11 m)	2.50" (63.5 mm)	0.875" (22 mm)

* Two-plate construction.

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Several features of the system require explanation. The torpedo bulkhead was constructed in two layers of high-strength steel plates below the lower deck. It was reinforced by vertical I-beams spaced four feet apart. This construction made it very rigid. After tests on Job 74 had been completed, it was noticed that there was some leakage in riveted joints due to bulkhead deflection. A conclusion drawn from this test was that the welding of the thick "D" and "D1" quality steel appeared to decrease the torpedo bulkhead's ability to withstand the stresses generated by an underwater explosion. In trial 5 of Job 74 (a replica of the aircraft carrier *Ark Royal*), some leakage was still experienced. The only difference between the two underwater defense systems was that trial 4 had 0.875-inch steel plates while trial 5 had a single plate of 1.47-inch "D1" steel. Therefore, bulkhead thickness varied in the *King George V*; whenever a fourth void space could be provided inboard, the bulkhead plating was 0.75 inches, otherwise it was 0.875 inches. The outboard bulkheads were 0.375-inch "D"-quality steel that could deflect or bend elastically and plastically under explosive-induced loads. Tests confirmed that the energy of an underwater explosion would be largely absorbed by the ship's side and cofferdam structure and spread by the liquid barrier. The bulkhead could withstand pressures reaching it. In the after portion of the armored citadel, where the volume of the underwater body decreased rapidly, the torpedo bulkhead was brought inboard to provide additional depth in the "Y" turret area. This produced a discontinuity in the structure and created a point of weakness.

The *King George V*-class ships had a standard simple double bottom, four feet deep under magazines and the propulsion plant, liquid-loaded to limit damage and flooding subsequent to rupture. The propulsion plant was extensively subdivided, longitudinally and transversely, all turbine sets were in individual compartments, and two boilers were in each fireroom—insurance against total power loss through flooding from a single explosion, such as a mine. Data from Job-74 guided structural, electrical, and machinery arrangements to minimize flooding or serious damage affecting buoyancy and stability. It was the designers' opinion that no form of underbottom protection could be devised which would prevent the effects of an underbottom explosion from doing considerable damage inside the ship. Therefore, bulkheads between major propulsion components were specifically designed to prevent flooding between adjacent machinery spaces. Boiler and engine rooms were so separated that any two shafts could remain in operation after a single underbottom explosion.

A triple bottom was considered during early design phases, but rejected—aside from the disadvantage of increased weight—because the propulsion plant would have to be elevated, producing an intolerable increase in the vertical center of gravity, which was calculated to be as high as was acceptable for satisfactory stability. Also, clearance for the boilers would have required an unacceptable increase in hull depth and the vertical extent of the side armor belt.

Subdivision and Stability. The *King George V* had nineteen watertight compartments; during the early design the Board of the Admiralty required metacentric

heights of six feet in the standard condition and eight feet in the full-load condition. It was estimated that these could be achieved with a beam of 103 feet. Stability particulars as calculated and those of the *Howe* in service after an inclining experiment on 6 May 1944 are summarized in Table 5-9.

TABLE 5-9
Stability Characteristics

Condition	Displacement	GM	Maximum Righting Lever	Angle	Range
Standard (Designed)	35,900 tons (36,400 mt)	6.75' (2.06 m)	4.85' (1.48 m)	36.5°	64.5°
Full Load (Designed)	40,990 tons (41,650 mt)	8.51' (2.59 m)	5.35' (1.63 m)	37°	72.5°
Light (<i>Howe</i>)	39,008 tons (39,634 mt)	4.97' (1.51 m)	3.60' (1.10 m)	33°	58.5°
Full Load (<i>Howe</i>)	44,512 tons (45,226 mt)	7.25' (2.21 m)	3.98' (1.21 m)	34°	65.5°

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Radar. Development of naval radar in the United Kingdom began in 1935. The first marine radar set was tested aboard the minesweeper *Saltburn* in 1936. An experimental British radar, Type 79Y, was installed in the cruiser *Sheffield* in August 1938; a second set was later installed in the *Rodney*. This equipment could detect aircraft at an altitude of 10,000 feet at a range of 53 miles. Development of the Type 79Y continued; the power was increased, and a barrage predictor was fitted to the system. This became known as the Type 279 radar. When war was declared, research was under way on a multipurpose set with surface-warning and ranging capabilities, as well as detection. A three-meter Type 281 radar installed aboard the cruiser *Dido* in September 1940 featured long-range warning, antiaircraft rangefinding, and main armament rangefinding, substantially diminishing the need for reconnaissance or spotting aircraft. In January 1941, the *Prince of Wales* received the Type 281 radar, capable of detecting battleships at 10 miles and aircraft at ranges of 60 to 110 miles. Consequently, the aircraft complements for the *King George V*, *Howe*, *Anson*, and *Duke of York* were deleted. Throughout the war, these ships carried the latest types of radar. The radar antennae and their associated gear imposed weights and loads on the masts, exceeding design anticipations, but the tripod design was justified when the *Duke of York* had half her port strut to the mainmast severed by a shell splinter from a 283-mm shell fired by the *Scharnhorst*, but returned to port with the mast in position despite bad weather. Radar installations in these ships, after 1944, are tabulated in Table 5-10.

After the loss of the *Prince of Wales*, the British fitted an ABU (Auto Barrage Unit) Mark I system to the *Duke of York* for defense against aircraft by the main-battery guns using preset fuzes and radar range-triggered firing. The object was automatic salvo fire, with shells fuzed to burst when the aircraft reached a preselected range. The ABU fired only one salvo at each attacking aircraft, but it fired all the guns of the battery at the right instant to hit, whereas without it, it could only be hoped that one gun, by chance, would shoot down an aircraft. The normal method of use was to fire at the standard barrage range (1,500 yards), but other settings would be used. The limits were:

- Range 0-6,000 yards
- Time of flight 0-6 seconds

TABLE 5-10

Summary of Radar Equipment

Function	Type	Range (miles)	Number	Location of Aerials
Air search	281B(1)	120	1	Mainmast
Surface search	277P	25	1	Foretop
Target designation	293P	20	1	Foremast
14-inch fire control	274(2)	. . .	2	Two main directors
5.25-inch fire control	285(3) (4)	. . .	4	High-angle directors
Pom-pom fire control	282	. . .	7	All octuple pom- pom mounts except on "B" turret

(1) 279B in the *King George V*

(2) The 14-inch surface set was originally Type 284, which had a much smaller aerial array than the Type 274, which had a large "cheese box" array, stabilized in elevation.

(3) The *Duke of York* was fitted with two Type 283 sets.

(4) Type 275 replaced Type 285 in the *Anson* during her 1945 overhaul.

For most guns the time-of-flight setting restricted the upper range limit, as the range corresponding to a six-second time of flight was less than 6,000 yards.

Both the *King George V* and *Prince of Wales* had air-warning radar installed on their mainmasts and fire-control radar fitted to their two main-battery directors. The *Prince of Wales*, before sailing to Singapore, was fitted with surface-warning radar (Type 271) and a fire-control radar (Type 285) for the 5.25-inch guns, and Type 282s were fitted to each of the four pom-pom directors.

Propulsion Plant. In designing the *King George V* class, the first British battleships since the *Nelson* and *Rodney*, several essential requirements were set for the propulsion plant in addition to high speed and rapid acceleration or deceleration. Simplicity of design and accessibility were also of major importance due to the need to operate anywhere in the world with a minimum of dockyard maintenance. The essential requirement, however, was the limitation on standard displacement, which gave weight reduction a higher priority than technical efficiency.

Although advanced marine engineering had made available improved lightweight compact boilers and turbines, operating at higher steam pressures and temperatures to produce greater horsepower and higher speeds, prevailing conservatism influenced the steam conditions advocated for these ships. A comparison of boiler-turbine weight to shaft horsepower for several British battleships is shown in Table 5-11.

For the *King George V* class, steam conditions were set at 400 pounds per square inch and 700 degrees F, to produce normal maximum shaft horsepower of 100,000,

TABLE 5-11

Boiler-Turbine Weight Comparisons—British Capital Ships

	Constructed	Lb. per SHP
<i>Queen Elizabeth</i>	1912-1915	86.1
<i>Hood</i>	1916-1920	65.9
<i>Queen Elizabeth</i> *	1937-1940	43.9
<i>King George V</i>	1937-1940	37.3

* Reconstructed at Portsmouth

with a short-term overload of 110,000. This moderately high temperature and superheat offered the possibility of weight reduction, but also introduced many new design problems, such as metal behavior at high temperatures and pressures, proper de-aeration of boiler feedwater, and the strength of high-pressure piping.

The British navy had pioneered in the development of high-pressure, high-temperature steam machinery with an experimental installation in the destroyers *Acheron* and *Achates* in 1931. In these ships, steam at 500 pounds per square inch with superheat of 280 degrees F produced an operating temperature of 750 degrees. Service trials with those destroyers resulted in fuel consumption at the rate of 0.608 pounds per shaft horsepower per hour, substantially lower than in sister ships. The plants had poor reliability, as regrettably they were never thoroughly tested on shore. No records of malfunctions and corrections were kept to help marine engineers avoid problems in future designs, so designers of the *King George V* class could not benefit by that costly experiment. By 1935, British power plants on land operated at pressures up to 1,800 psi and temperatures of 900 degrees F, with an average of 400 psi and 750 degrees F. However, experience with the *Acheron* and *Achates* indicated that reliability of well-proven machinery design should be emphasized, rather than increased efficiency. With war a distinct possibility, the Royal Navy did not wish to employ untried technologies beyond the production capabilities of their marine engineering industry.

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Boilers. The *King George V*-class ships were equipped with eight three-drum type watertube boilers built to Admiralty specifications. Since the construction of the *Nelson* and the *Rodney* (with 250 psi 575 degrees F plants), boilers had increased in size, and improved design had raised their efficiency. Nevertheless, steam demands had also increased, due to the needs of the main propulsion plant, greater use of turbogenerators, and other steam-driven auxiliaries. The total heating surface of the boiler plants had increased from 51,756 sq. ft. in the *Nelson* and *Rodney* to 78,144 sq. ft. in the *King George V* class. The 325-ton boiler installations in the former produced 45,000 shaft horsepower; the 416-ton installation in the latter produced more than 100,000 shaft horsepower. The eight boilers were more economical in space and fuel than the twenty-four boilers in the battlecruiser *Hood*. Fewer, but larger, boilers lowered the weight per unit of heat delivered, as did increased boiler efficiency and consumption of fuel per unit area of heating surface.

The development of the Yarrow three-drum, small-tube boiler from the *Hood*-type of 1916 to the relatively highly rated unit for the *King George V* class involved many design problems. The most fundamental of these concerned adequate water circulation in the generator and fire-screen tubes, separation of the steam-water mixture leaving the risers to avoid water carry-over to the superheater and steam entrainment in the downcomers, and the regulation of the feed supply, particularly when changing power to avoid false level readings caused by "swell" phenomena.

The requirement for a furnace large enough to burn sufficient fuel, yet restricted in height, led to a design with a very shallow inverted "v" formed by the steam drum and water drums, making the vertical head inadequate for natural circulation with the colder generator tube risers acting as downcomers. Entrained steam in the downcomers also adversely affected circulation, but this condition was partially corrected by fitting a circulation augmentor (a steel trough) in the steam drum. Further development of steam drums, internal gear, and feed-regulating equipment reduced the instability of the water level and the effect of "swell" to an acceptable degree.

With increased working pressure and superheat, other modifications in construction were necessary. To obtain the maximum rolling length of tube in the tube plates of the steam and water drums, the tubes had to be bent so as to enter the drums

normal to the tube plates, and arranged to provide the gap into which the superheater fitted. To obtain relatively high superheat, the superheater had to be placed only five rows back from the furnace. High temperatures at this point caused considerable difficulty in designing the superheater tube support.

Two three-drum, small-tube, forced-draft type boilers with a common stoking space were fitted in each of the four boiler rooms. Uptakes were reduced in size and boiler-room pressure increased to improve armor protection by reducing the size of openings required in the armor deck for passage of the exhaust gases.

Turbines. Turbine design was predicated upon a normal maximum output of 100,000 shp and an emergency overload of 110,000 shp. A speed of 28.5 knots was expected at standard displacement and 27.5 knots at full-load displacement on normal output; corresponding speeds at overload condition were 29.25 and 28.25 knots. The turbine unit was a low-speed type (2,257 rpm) coupled to a single reduction gear which produced 236 rpm at the propeller shaft.

Metallurgical factors dictated pressure and temperature, while British manufacturing methods were not precise enough to permit the use of double-reduction gears. The need for improved gear-cutting technique was recognized, and the National Physical Laboratory helped develop instruments for checking gear accuracy which helped improve gear-cutting standards, but at no time during World War II was the United Kingdom able to match the United States in the high accuracy of machining a gear-tooth profile for a locked train double-reduction gear. Such gears were first installed in the Royal Navy in the frigate *Loch Tralaig* in 1948.

The steam path for the high- and low-pressure turbines was in series, but each turbine drove a separate shaft which was coupled to the main shaft through two helical gears. An astern turbine was incorporated in the exhaust casing of the low-pressure turbine, and the cruising turbine was directly attached to the high-pressure turbine. They operated at 350 psi and 650°F.

Electric plant. While the *Nelson* was under construction, mechanical problems were experienced with her diesel generators. A decision was later taken against their use as the prime source of electric power by the Directors of Electrical Engineering (DEE) and Torpedo and Mining (DTM) who claimed that they took up more weight and space, were less reliable, and created difficulties in the provision of clear runs for their exhausts. In 1931, an electrical fire in the cruiser *Berwick* revealed some problems in the sequences of overload operating between the supply, ring main, and branch breakers. Some objections were raised by the DTM and DEE to the placement of generators in the *Arethusa*-class cruisers, because they were too close together for adequate ring main distribution. In 1932, trials conducted on the *Berwick* showed that the problem of overloading was indeed severe. To correct this, the instantaneous trip gear was ordered removed from the supply breaker overloads. The naval treaties and a severe economic slump had forced some simplifications in the design and layout of electrical systems in warships of cruiser size or larger.

In 1934, a proposal to distribute electrical power by the use of generators and switchboards was dismissed by the DTM. Thus, when the detail design of the *King George V* began in 1936, a ring main distribution system had to be used. In July 1938, an electrical accident on the *Rodney* indicated a serious problem in the sequence of overloads, which resulted in some consideration of removing the group change-over system from the *King George V* class. It was decided that it would be impossible to make such a change in view of space requirements, weight considerations, and the quantity of work then completed. In March 1939, the electrical system of these battle-

ships was questioned again, and after considerable discussion, it was decided that the ring main would be divided into two separate systems, one forward and one aft.

The total ship service electric output of 1980 kw was supplied by six 220-volt 330-kw DC turbogenerators. Two additional 330-kw diesel generators provided emergency power. The generators were attached to the forward and aft ring mains through fuze release switches, which permitted the isolation of a generator, but only by use of voice communication from damage-control central. The cause of failure of the system in the *Prince of Wales*, which was a major factor in her loss, was attributed to equipment design, which did not withstand the conditions to which it was subjected, and the overloads and fuzes which did not function as the designer had intended.

The low electrical demands of this battleship class were a result of the fact that most of the main auxiliary machinery was steam driven, while motor-driven auxiliaries were generally installed as emergency units. The only electrically driven major auxiliary was the steering gear, which was also equipped with emergency steam power. Galley ranges and ovens were oil-burning types. The 14-inch guns and turrets were hydraulically powered, a time-honored British practice. The 5.25-inch guns were equipped with an electrohydraulic drive. Hydraulic power was used for the main armament, because British engineers were convinced that there was no equivalent to the space necessary in taking hydraulic piping into the mounting, and, of course, no provision had to be made for hydraulic engines. Hydraulic power was also used because it was considered more reliable and positive and less likely to be adversely affected by the shock of firing or the impact of enemy projectiles.

Endurance for this class was originally set at 10,000 miles at 14 knots, but later changed to 14,000 miles at the 10-knot trial condition. From design data, Vickers Armstrongs quoted the range as 3,100 nautical miles at 27 knots, 4,000 miles at 25 knots, 5,750 at 20 knots, 10,250 at 15 knots, and 14,500 at 10 knots. Such performance was never approached in service. The difference between the "as-designed" and operational figures was due to the manner in which the designers determined the endurance. Bunker capacity had to be sufficient for:

- Two hundred hours at 16 knots with steam available for 18 knots, plus eight hours at full speed, plus sixteen hours at 18 knots and twelve hours at 16 knots, the latter two with steam available for full speed. All conditions assumed ship six months out of dock. Range—3,896 nautical miles; fuel—2,020 tons.
- Reserve for bad weather and possible damage, 35 percent of the above. Fuel = 710 tons.
- Necessary extra fuel to give ship 14,000 miles at the 10-knot trial condition. Fuel = 600 tons.

The total was 3,330 tons. The naval constructors thought that 3,700 tons (which included diesel oil) should be sufficient, and the original estimate of 4,000 tons was reduced. The ships could undoubtedly attain the first requirement, as they could cover 3,900 miles at approximately 22 knots steady speed. The fault lay in the specified endurance of nearly ten days (236 hours) and the vast difference between fuel consumption under trial conditions and in service—the difference between propulsion-only and all-purpose totals. The trial fuel rate figure was calculated as 2.4 tons per hour for 14,000 miles at 10 knots, but in practice it was 6.5 tons per hour at 10 knots, and 1.7 tons per hour in port. The actual endurance was about half the 14,000 miles specified, and the naval staff erred in not requiring a more realistic figure.

War service indicated the need for greater endurance. In 1945, double-bottom spaces forward of the citadel and in the wing tanks between the armored shelf and the

lower deck were converted to fuel-oil tanks. This reduced the effectiveness of the underwater protection system, and the increased weight reduced the freeboard. On the completion of these changes, the *Anson* carried 4,202 tons of fuel oil, plus 183 tons of diesel oil. Her endurance was projected to be 16,000 miles at 10 knots. This change in tankage represented a 15 percent increase in fuel capacity. The *Duke of York* had her fuel capacity increased approximately 7.5 percent. The figures shown in Table 5-12 for endurance on the *Duke of York* and *Anson* are at full-load displacement, three months out of dock, average weather and sea conditions, and postwar conditions at displacements in excess of 40,580 tons.

TABLE 5-12

Endurance Characteristics for Duke of York and Anson

Speed	Nautical Miles	
	<i>Duke of York</i>	<i>Anson</i>
27	2,400	2,600 (227 rpm)
25	3,200	...
24	...	3,790 (194)
21.5	...	4,760 (172)
20	5,100	...
17.5	...	6,400 (136)
15	6,000	6,800 (116)
10	5,600	6,100 (75)

Combat operations proved that these ships had poor endurance for several reasons. The adoption of a saltwater displacement system allowed 150 tons of the fuel oil to become contaminated, and only 100 tons of this could be gradually decontaminated. The water-fuel separation was poor and led to the formation of impurities in the superheaters ("slagging" or "bird nesting"), which caused overheating of the tubing and their eventual failure. The emulsion at the interface separated very slowly. In addition, staff requirements were influenced by existing restraints which enforced a reduction in stability elsewhere. Priority was given to efficiency at *full power* rather than *cruising speed*, and the lack of test facilities on shore hampered steam-machinery development in the Royal Navy prior to World War II.

Reliability was stressed in the design of the propulsion plant, with efficiency of secondary importance, but this resulted in high fuel-oil consumption. Admiral Tovey was understandably concerned with the performance of his flagship, the *King George V*, when she operated with the USS *Washington* during 1942. The British battleship burned 39 percent more fuel at lower speeds; at higher speeds, the *Washington* still maintained fuel superiority. Her overall characteristics permitted twice the cruising radius of the *King George V* at low speeds, and nearly 20 percent more at higher speeds.

Operations revealed complications in the fuel-oil system; to use oil in the wing tanks and maintain the liquid level in the side protection system, it was necessary to admit seawater to the tanks, thereby maintaining liquid levels as required for protection, at the price of partially contaminating the fuel. The water displacement system was very complex in design and operation; it involved opening watertight hatches and doors and required extra men to operate the valves.

The turbines drove four three-bladed manganese bronze propellers of 14.5-foot diameter and 15-foot pitch, capable of transmitting 27,500 shaft horsepower each at 236 rpm. The disc overlap for inboard and outboard shafts was 1.5 feet; tip clearance from the hull was 2.92 feet inboard and 2.33 feet outboard.

Hull Characteristics. The ships were wall-sided amidships with a tight bilge, the midship coefficient being 0.99, but with a fine hull form (block coefficient = 0.59) and no bulbous bow. The beam was smaller than in the *Nelson* and *Rodney*, but the stability requirements were greater than any previous British battleship. A moderately large metacentric height was chosen to limit the roll period—which, at fourteen seconds, was relatively fast for this type of ship—to reduce topside structural stresses, and to make fairly stable gun platforms. The square hull form and large bilge keels slightly reduced the roll. During the design, care was taken to prevent a repetition of the eleven-second roll period of the *Nelson* and *Rodney*, which interfered with gun laying and led to high angular accelerations and large structural stress.

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Welding. Much of the hull structure was riveted. Welding was considered but abandoned on the basis of the Job-74 experiments, except for structures not involved in longitudinal strength, support of mounts or turrets, or shock response. Studies indicated that, although welding might have been a better method to use in ship erection—especially in joining deck and shell plates—it would not replace riveting for several years; it offered economies in weight saving and prefabrication, but required new techniques yet to be devised for its employment in battleship construction. As war was imminent, potential delays resulting from the massive adoption of welding were not acceptable. Also, crack propagation under explosive attack was much less with riveted than with welded structure. Occasional rivet leaks were more than offset by expected superior damage resistance.

Displacement. The designed standard displacement of 35,900 tons might have been met, but the Admiralty removed all such restrictions when the Japanese failed to sign the 1936 London Naval Treaty. The calculated weight reached 36,727 tons in 1938; the *King George V* was delivered in 1940 with a full-load displacement of 42,245 tons.

The increased draft seriously reduced the freeboard, and most acutely at the bow; seaworthiness was particularly bad in head seas. Normally, the decreased freeboard would not have been critical, since ship designers always allow a margin for some weight increase, but in this class there was insufficient freeboard at the bow in the design as first completed. This same condition hampered the *Prince of Wales* in her action with the *Bismarck*. This problem originated in the requirement that "A" turret should be able to fire directly over the bow at a 0-degree elevation. This requirement was adhered to although the result could be foreseen; the ships were very wet forward, and spray washed over the forward turrets as the bow was easily buried in a light to moderate gale.

Barbette structure. The barbette armor, approximately 40 feet in diameter, was a rigid cylinder in a large area of relatively flexible weather-deck plating subject to severe strains. In heavy weather, fractures in the rivets joining the barbette to the deck plate let seawater seep into berthing areas and caused considerable inconvenience, until flexible sheet steel curtain plates were fitted between the top of the barbette angle and the barbette armor.

Rudders. The rudders presented another structural problem. Because of stability and speed requirements, areas in way of the rudders had a pronounced "Y" form with distinctive concave sections in the floor plates, so designed to prevent the shell plating from appreciably resisting lateral thrust on the lower pintle. The floor plates were connected to the shell by a single angle bar, single riveted on each flange. These rivets

took considerable fatigue loading in their first two years of service, due to high-speed maneuvering in all kinds of weather, and eventually failed, producing serious leaks in the steering engine room. The sideways movement of the rudder head top became so great that fracture of the stern casting was feared. By early 1944 this was eliminated in all existing ships by connecting the floor plates and the shell with double angles, and additional athwartships web frames were used to support the stern casting at the rudder gland.

Deck structure. The weather-deck forward, exposed to gun blast from "A" turret and, to a lesser degree, from "B" turret, was violently affected when the guns fired at low elevation. There was considerable movement of equipment in the vertical planes in areas between the main structural bulkheads. Damaged equipment, ventilation trunks, and electrical leads considerably inconvenienced the crew. Investigation of the problem determined that nonstructural bulkheads should terminate two inches below the weather deck, and that equipment should be deck mounted, not hung from bulkheads. Items hung from the weather-deck structure should have a good spring system incorporated in their supports.

Bridges. In these ships, the tall cliff-like front and sides of the bridge tower screened the forward part of the compass platform from the weather, but the admiral's bridge below was extremely drafty and unsatisfactory for cold-weather operations. Although studies were done, no improvements were ever made, and the bridge tower of the *Vanguard* was redesigned to prevent repetition of the problem.

Shock response. The effect of noncontact explosions was not fully understood or accounted for in structural or equipment design before World War II. Shock damage to machinery or electrical equipment was not considered serious enough to warrant testing or study, although Job 74 results did indicate that shock damage to equipment could be severe, whether from contact or near-miss explosions. Most equipment and their foundations were generally strong enough to withstand vibrations at high speed as well as the shock of firing heavy guns. After the *City of Paris* and the cruiser *Belfast* detonated magnetic mines which severely damaged structure and machinery, the effects of noncontact explosions were given increased attention.

In this and other cases, including near-miss bombs, machinery and electrical components were damaged more than ship's structure. The obvious but difficult and expensive remedy was to redesign the machinery foundations to better withstand shock. Some improvements were made, but most wartime solutions were of a makeshift nature. Postwar research into this phenomenon resulted in many new concepts. In the *King George V* class, after the *Prince of Wales* was lost, shock damage vulnerability was minimized as much as possible by structural modification.

Fresh-water system. The urgent need to place the *King George V* and *Prince of Wales* into service led to the acceptance of a known deficiency in the hot-water system which the fleet repair and dockyard services had to correct. This system used some galvanized piping because of a severe copper shortage, and the different materials caused corrosion. When copper later became plentiful, the problem was eliminated in later ships of the class.

Ventilation. The ventilation system was designed in accordance with the recommendations of the 1938 Ventilation Committee, but under battle conditions there were high temperatures in certain engineering spaces and the mess areas on the middle deck. Other weaknesses were revealed when the *Prince of Wales* operated in the

tropics and was damaged. Steaming under tropical conditions required more ventilation than had been provided. When the ship was attacked by Japanese aircraft on 10 December, she was not at 100 percent closure in so far as the ventilation system was concerned. When the ship listed heavily to port, the unsecured trunks contributed to progressive flooding. The vent fans for the "X" engine room lost power. Without supply and exhaust fans, the engine room became untenable, although the turbines and other equipment in the space were not damaged. To prevent the recurrence of such a situation in other ships of the class, steam-driven fans were installed in all main engine rooms and important auxiliary machinery spaces, except those containing electric generators, where power for the fans was taken directly from the generators. To reduce the temperatures in the machinery spaces, more lagging was used on the machinery and piping.

Summary. The *King George V*-class ships illustrate the fact that years of peace inevitably result in increased weaknesses and operational deficiencies in warships. These points, evident in the design of these ships, were further accentuated by technical limitations and the overall need for economy. The long inactivity in capital-ship construction after the completion of the *Nelson* and *Rodney* and the severe British economic recession in the early thirties hampered design efficiency. Reduced ship construction broke up highly skilled design teams, dispersed a specialized labor force, and caused severe shortages in armor and gun supply. After the ratification of the Washington Treaty in 1922, only three British firms continued producing armor steel, with a total annual capacity of 3,500 tons. Despite Admiralty inducements to stimulate production, by 1938 it was necessary to purchase 12,500 tons of armor from Czechoslovakia. Shortages in gun-mounting and fire-control gear manufacture delayed construction and made it possible to reduce armor demand. All these conditions contributed to a delay in completing the ships.

Torpedo damage to the *Prince of Wales* during the first Japanese air attack revealed several weaknesses in the side protection system of these ships. The torpedo bulkhead should have been located as far away from the side shell as was possible, and should not have been stepped in so radically; however, this would have required increased beam and displacement. Confidence in the riveted connections in the system also may have been unwarranted. In Job 74, where an explosive charge of 1,000 pounds of TNT was detonated some 15 feet below the design waterline of 28 feet, damage to the welded section of the torpedo bulkhead was extensive, while that to the riveted portion was small and the leakage was easily controlled. It was on the record, however, that the riveted portion was not subjected to as high a stress level as the welded area, and according to the Bucknell Committee report on the loss of the *Prince of Wales*, the use of riveting was "not . . . entirely justified." The designers of these ships considered that if riveting was employed, adequate protection against torpedoes would be afforded. This proved incorrect, as the spaces inboard of the torpedo bulkhead flooded rapidly and completely.

In reviewing the loss of the *Prince of Wales* to determine how and why a brand-new battleship sank, many factors must be considered. The inability to establish an effective flooding boundary and the extensive electrical power failure, which left many spaces without light and immobilized vital equipment (such as the steering gear and pumping facilities), were major reasons for the ship's loss. The power failure also caused a disruption of the ventilation system in the stern portion of the ship and immobilized most of the 5.25-inch guns. The extent and magnitude of the flooding raises a serious question about the effectiveness of the torpedo protection system,

since the Japanese aerial torpedo charges were less than half as powerful as the design resistance of 1,000 pounds.

In general, a heavy underwater explosion in contact with the side of a battleship with a torpedo defense system like that of the *Prince of Wales* will open a number of wing tanks to the sea. Those tanks which are empty will flood rapidly and cause a large off-center weight and an immediate list. If the holding bulkhead remains in place, some leakage could occur through torn plates or rivet holes. Also, a very large explosion against a protective layer that is not complete or properly liquid-loaded may result in the failure of the torpedo bulkhead, with immediate flooding of vital inboard compartments. Such explosions will usually destroy the deck over the torpedo protection system, and flooding will progress to this deck level. If the holding bulkhead is not extended another deck level, then flooding will occur in relatively high spaces, making it more difficult to contain.

The depth at which a torpedo strikes is also important. Torpedoes striking just below an armor belt or near the turn of the bilge produce more severe damage than those striking at mid-depth. Shallow-striking torpedoes will cause more damage to the deck over the torpedo protection system, whereas deeper ones will cause the holding bulkhead to leak at its lower extremities. In any event, once the torpedo strikes, the prompt removal of list and trim is essential to prevent progressive flooding through nontight high subdivision from damaged compartments to adjacent ones and to lessen the ship's vulnerability to further damage, particularly on high deck levels with no side protection system.

In evaluating what caused the large port list to develop in the *Prince of Wales* within the relatively short time span of ten to fifteen minutes, available survivor testimony and postwar research has established the following concerning the damage sustained during the first torpedo attack:

- The deck over the torpedo protection system was breached, and there was a considerable ingress of water into the bounding spaces.
- Vital spaces bounding the torpedo impact area were flooded instantaneously.
- Progressive flooding of spaces bounding those mentioned above occurred through hatches and doors left open by a fleeing crew, and through ventilation trunks and air escape pipes which had not been equipped with the proper watertight closures.
- The explosive charges of the Japanese torpedoes in the initial attack were only 330 pounds of TNT/Hexyl.

Much study of the underwater protection system, its operation and design, analysis of Japanese aviator and survivor testimony has been conducted by the authors, as well as further assessment and study of the findings of the two committees set up to determine the cause of the ship's loss. Without question, the ship was hit by one torpedo at frame 289; evidence was obtained of the damage by a postwar diving survey. The damage sustained near frame 206, however, was unusually severe, and Japanese aviators and Captain Tennant of *Repulse* noted its unusual intensity in reports of the action. Damage to the ship in this area has been the subject of considerable study by the authors, with the three following hypotheses:

- The ship was hit by one torpedo near frame 206 (this being near a major transverse watertight bulkhead). Part of the transverse bulkhead buckled for a considerable distance inboard permitting flooding beyond the torpedo protection system. The resulting ingress of water was so great that it led to progressive flooding through ventilation trunks, which were not equipped with the proper watertight

closures, and air escape pipes, which were not carried up to the upper deck, fitted with valves, or which failed under a shock loading.

- The ship was hit by one torpedo near frame 206 which triggered the detonation of a second trailing close behind the first. The explosion of a second, even mini-seconds after the first, would have sent a pressure pulse against already weakened structure, causing failure of the holding bulkhead and extensive flooding inboard. It should be noted that the Japanese planes attacked in groups of three and in tight formation, so it was certainly possible for this to happen. This also seems more plausible in terms of the damage and flooding sustained and the size of the charge in the Japanese torpedo warheads.
- The ship was damaged by a near-miss bomb in August 1940 in an area where a Japanese torpedo subsequently struck (namely frame 206 on the port side). The damaged shell and framing may have not been fully replaced, and if so, the structure would have been weakened and the side protection system would have not been able to perform to expectations. Records of the repair are not available; however, the ship was rushed to completion and repairs of the ship's side in way of the bomb damage may have been limited to the replacement of plating. When the torpedo hit, this soft portion of the side protection system, the damage sustained would have been more severe than in other parts of the ship.

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Careful review of the evidence, Job-74 results (see Appendix A), and the design of these ships leads the authors to conclude that the events in the third narrative seem most plausible. Whatever the ship's condition, the fact remains that the ship was fatally open to the sea from the after end of the port outer shaft alley to "B" engine room as a result of a shaft warped from a torpedo hit on its outer shaft strut and severe damage near bulkhead 206. The explosion had carried away the propeller and strut and bent the shaft so that it too carved into the shell plating, thereby increasing the flooding area. Even if the ship had managed to survive longer, the Japanese still had enough planes to make further attacks.

Nevertheless, the loss of the *Prince of Wales*, which was a new warship with all the latest British technology, was a severe shock to British naval constructors and caused them to reevaluate the *King George V*-class design. Important conclusions drawn from this study were:

- The space on the inboard side of the torpedo bulkhead should not flood. Slight leakage would have been acceptable.
- The space at the top of the bulge should be an essential part of the torpedo protection system and should not be used for ship purposes, such as washrooms.
- The middle deck which formed the upper boundary of the torpedo defense system in these ships should be increased in strength with vertical access limited to manholes. No leakage should be permitted above this deck.
- Turbogenerators and diesel generators should not be located near the torpedo bulkhead. This ideal arrangement could not be used in the *King George V*-class battleships. An alternate, but less desirable, solution was to attempt to ensure the tightness of the torpedo bulkhead.
- Some of the ventilation fans should be steam driven.

A review of the design led to the following improvements in the four surviving sister ships:

- Accesses to all vital compartments were trunked.
- Better watertight closure was adopted for ventilation trunking.

- More extensive use was made of sound-powered telephones.
- Antiaircraft armament was increased.
- Living spaces over the side protection system on the middle deck were relocated. This led to some crowding in berthing areas in other parts of the ship.
- The aircraft complement was eliminated, permitting the use of the hangar for accommodations and some of the deck outboard for light machine guns.

Thus, with all the changes mentioned, the *Howe* in 1945 displaced some 45,226 tons, whereas the *Prince of Wales* in a comparable condition some four years earlier displaced only 43,786 tons.

Prime Minister Churchill considered these ships to be gravely undergunned, which was true; additionally, the gun mountings had many flaws, particularly in the quadruple turrets, which were revealed in battle. The decision to fit the ships with 14-inch guns was unfortunate, but necessary if they were to be completed in 1939. The later "B" turret redesign delayed the completion of the *King George V* and *Prince of Wales* almost a year, and resulted in ships with ten 14-inch guns.

The unfortunate, but necessary, selection of a 14-inch armament was strictly a matter of time and principle. The Royal Navy felt treaty bound and yet wanted to start construction in January 1937, at which time the 1936 London Naval Treaty prohibited new construction of battleships with guns of greater than a 14-inch bore. The Admiralty was in fact in favor of a battleship design featuring nine 15-inch guns, and only because the United States Navy agreed to the 14-inch limit was the smaller caliber chosen. Limited industrial facilities precluded the parallel development of two major caliber turret designs. Later that year, after the Japanese had refused to ratify the treaty, the limit reverted to 16 inches. The early 1937 start promised delivery of the lead ship in 1939. Unfortunately, the subsequent decision to change "B" turret to a twin configuration in order to save weight cost the Royal Navy some six months of design work (production problems contributed several months more), similarly delaying construction, as turrets normally governed the speed of construction of capital ships. These delays frustrated the time-saving consideration that had influenced the deliberate acceptance of a potentially inferior armament. Had the construction been deferred a few months, until a larger caliber was permitted by the treaty, the two ships would not have been ready until 1941 at the earliest.

In *The Bismarck Episode*, Captain Russell Grenfell wrote:

To excuse and explain these long periods of semi-inefficiency, the gunnery authorities of the navy began to speak of them as being due to "teething troubles" in new-design mountings. It was a very dangerous slogan, tending to obscure . . . the cardinal fact that a new ship, if she is to fight at all, must be ready to fight at once and with all her armament. . . .

By 1941, this "teething trouble" slogan had got a serious hold on the Navy Thus, Captain Leach of the *Prince of Wales* referred in his report of the action to "the practical certainty that owing to mechanical teething troubles a full output of the main armament was *not to be expected*." Again, Rear Admiral Wake-Walker's dispatch spoke of the *Prince of Wales*'s new turrets "in which mechanical breakdowns had occurred and *were to be expected!*" And the commander-in-chief himself could allude to her turrets which, "of a new and untried model, were known to be liable to teething troubles!"

Still, the early 14-inch hits by the *Prince of Wales* on the *Bismarck* were the most decisive that that ship sustained; they forced a German change in plans, and caused an early return to Brest. Furthermore, Captain Grenfell's criticism is somewhat harsh in the case of the *Prince of Wales*, since she was in battle only two weeks after builder's trials and lacked any post-trial adjustments.

Poor endurance, another characteristic of these ships, embarrassed them in Pacific operations; twice they had to refuel from U.S. frigates. Contributing to this low endurance were the Parson turbines—standard British equipment for some time before the class was designed—and the large number of steam-driven auxiliaries.

The ships had a very low freeboard, reduced during the war by many additions and alterations. The problem was the result of an outmoded requirement for low-elevation forward firing of "A" turret. As a consequence, the ships were constantly washed down in a seaway, and in some instances spray hampered the "A" and "B" turret rangefinders. Also, in action with the *Bismarck* the gun crew of turret "A" had water entering the turret and causing some problems.

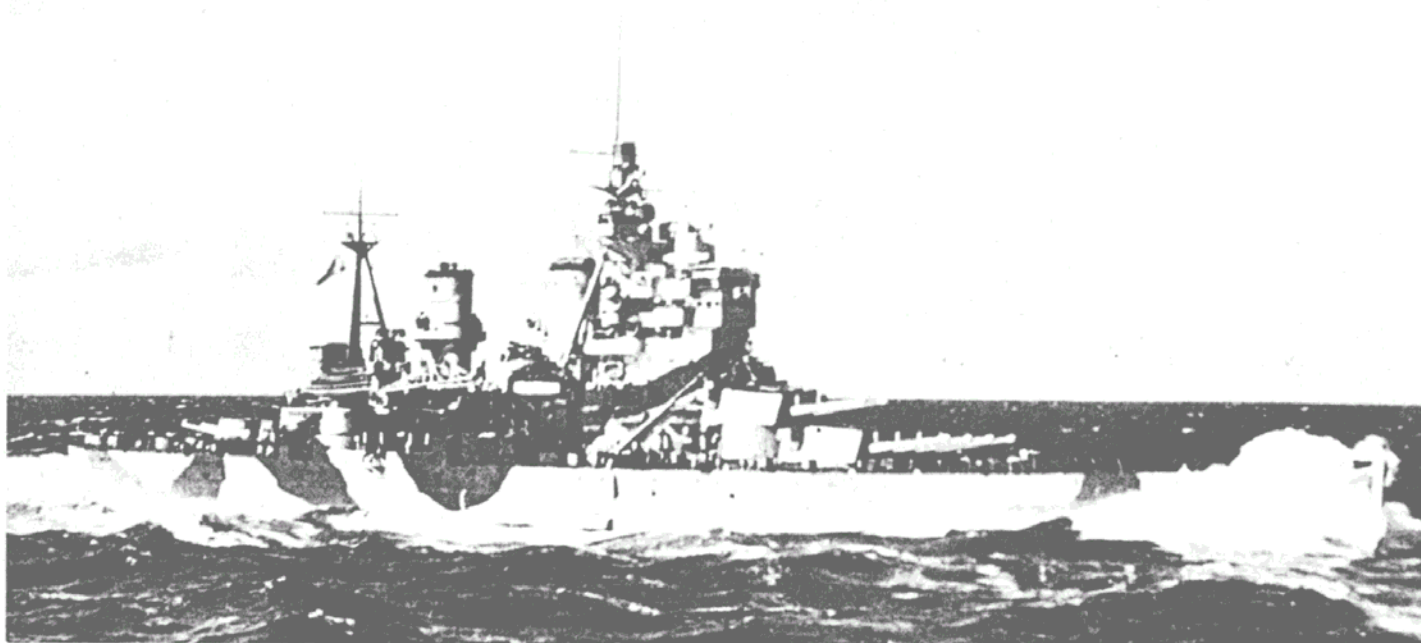
The loss of the *Prince of Wales* revealed that propeller shaft glands were susceptible to leakage because of shaft and strut damage. When the shaft was bent, it kept turning and ultimately wrecked the shaft glands on all bulkheads of the shaft alley, greatly increasing the flooded area. Any yielding of the thrust block supports would increase the shaft deflection considerably—with perfect free ends the deflection might amount to four inches before any part of the shaft touched the engine room bulkhead. Considering the hull oscillations after this hit and the subsequent damage observed by postwar divers, it seems reasonable to assume that flooding openings in these shaft glands were several inches in width. Shaft gland distortion was later eliminated by the design of flexible bulkhead glands which allowed some degree of bulkhead distortion without rupture or serious damage to the glands. The spacing of the line bearings was also reduced, and locking gear was fitted to the shaft.

Armor protection for these ships varied from excellent to poor. Deck protection performed as expected, as was demonstrated by the bomb hit sustained by the *Prince of Wales*, but conning tower protection was very poor. Horizontal protection was equal to that of certain other battleships completed in World War II. Side protection was adequate against 15- or 16-inch shellfire at normal battle ranges.

The Royal Navy entered World War II with the belief that superstructure protection was not necessary and should be severely limited; but the battle experiences of the *Prince of Wales*, as well as of German and United States battleships, indicated that ship-control positions required some protection. Stability and weight considerations clearly played an important part in the British decision to limit superstructure armor. Heavier main armament and increased armor protection forced the severe reduction of topside armor, the reduction in freeboard, and the elimination of two 14-inch guns in "B" turret.

Despite the many technical shortcomings of these battleships, they gave magnificent service during one of the most critical periods in the history of the United Kingdom. The loss of the *Prince of Wales* was a real shock to a nation weary of war, but it forced the British naval constructors to review some of their conclusions regarding warship design and construction. Of course, many of the criticisms of the design cited in this text have been made with the precious advantage of hindsight; during war the cures for some faults cited were expensive, time consuming, and in some instances not practical.

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The Anson is shown in August 1943, operating off Norway during Operation Governor. The Anson spent much of her career operating in support of convoys to northern Russia. (Imperial War Museum)



The Howe in August 1942, shortly after completion. The last of the class, the ship carried no aircraft, but had an improved antiaircraft machine-gun battery, and the most modern available electronics.

Name	<i>King George V</i>	<i>Prince of Wales</i>
Builder	Vickers Armstrongs Walker-on-Tyne	Cammell Laird Birkenhead
Laid Down	1 January 1937	1 January 1937
Launched	21 February 1939	3 May 1939
Commissioned	30 September 1940	19 January 1941
Operational	19 January 1941	22 May 1941
Disposition	Purchased for scrap on 17 December 1957 and broken up by Shipbreaking Industries, Ltd., Faslane	Sunk by Japanese aircraft in South China Sea at 3°33.6' North and 104°28.7' East on 10 December 1941

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Name	<i>Duke of York</i>	<i>Anson</i>
Builder	John Brown and Co., Clydebank	*Swan Hunter and Wigham Richardson, Wallsend
Laid Down	5 May 1937	22 July 1937
Launched	28 February 1940	24 February 1940
Commissioned	20 August 1941	14 April 1942
Operational	22 December 1941	September 1942
Disposition	Purchased for scrap on 18 May 1957 and broken up by Shipbreaking Industries Ltd., Faslane	Purchased for scrap on 17 December 1957 and broken up by Shipbreaking Industries, Ltd., Faslane

Name	<i>Howe</i>
Builder	Fairfield Shipyard, Govan
Laid Down	1 June 1937
Launched	9 April 1940
Commissioned	2 June 1942
Operational	December 1942
Disposition	Purchased for scrap and broken up by T. W. Ward and Co. on 27 May 1958

Displacement

King George V

(1940)	38,031 tons (38,641 mt)	Standard
(1940)	41,630 tons (42,298 mt)	Trials
(1940)	42,237 tons (42,905 mt)	Full Load
(1944)	44,460 tons (45,173 mt)	Full Load

Prince of Wales

(1941)	42,100 tons (42,775 mt)	Trials
(1941)	43,786 tons (44,469 mt)	Full Load

Duke of York

(1941)	42,550 tons (43,232 mt)	Trials
(1944)	44,790 tons (45,509 mt)	Full Load

Howe

(1942)	42,530 tons (43,212 mt)	Trials
(1942)	43,337 tons (44,032 mt)	Full Load
(1944)	44,512 tons (45,226 mt)	Full Load
(1945)	45,226 tons (45,952 mt)	Full Load

Anson

(1942)	42,600 tons (43,296 mt)	Trials
(1945)	45,360 tons (46,088 mt)	Full Load

* Machinery for *Anson* constructed by Wallsend Slipway Company.

Dimensions

King George V

length overall	745' 0.13" (227.08 m)
length between perpendiculars*	700' 0.25" (213.37 m)
waterline length	740' 0.25" (225.56 m)
maximum beam†	112' 4.25" (34.24 m)
waterline beam	103' 2.56" (31.46 m)
depth at side	51' 1.31" (15.60 m)
mean draft at 44,460 tons (45,173 mt)	34' 1.75" (10.41 m)

Prince of Wales

length overall	745' 1.63" (227.12 m)
length between perpendiculars*	700' 1" (213.39 m)
waterline length	740' 1" (225.58 m)
maximum beam†	112' 4.88" (34.26 m)
waterline beam	103' 2.19" (31.45 m)
depth at side	50' 10.25" (15.50 m)

Duke of York

length overall	745' 0.63" (227.10 m)
length between perpendiculars*	699' 11.88" (213.36 m)
waterline length	739' 11.88" (225.57 m)
waterline beam	103' 1.75" (31.44 m)
depth at side	50' 10.38" (15.50 m)
mean draft at 44,790 tons (45,509 mt)	34' 4.25" (10.47 m)

Howe

length overall	745' 0.25" (227.08 m)
length between perpendiculars*	700' 0.25" (213.37 m)
waterline length	740' 0.25" (225.56 m)
maximum beam†	112' 6.25" (34.29 m)
waterline beam	103' 0.75" (31.41 m)
depth at side	50' 10.50" (15.50 m)
draft at 45,360 tons (46,088 mt)	34' 10.50" (10.63 m)

Anson

length overall	744' 11.50" (227.06 m)
length between perpendiculars*	699' 11.50" (213.35 m)
waterline length	739' 11.50" (225.45 m)
waterline beam	103' 0.62" (31.41 m)
depth at side	50' 10.75" (15.51 m)
draft at 44,512 tons (45,226 mt)	34' 2.25" (10.42 m)

Hull Characteristics at the Full Load Waterline—*Anson* (1945)

Displacement	45,360 tons (46,088 mt)
Mean draft	34' 10.5" (11.442 m)
Hull depth amidships	50' 10.5" (16.691 m)
Freeboard at bow	22' 8.5" (7.447 m)
Freeboard at stern	17' 2.75" (5.653 m)
Frame spacing	2' 0.0" (0.610 m) armor box 3' 0.0" (0.914 m) ends
Block coefficient	0.596
Prismatic coefficient	0.602
Waterplane coefficient	0.690
Midship section coefficient	0.991
Tons per inch immersion	125.2 (50.1 mt/cm)
Moment to trim one inch	4870 (594 m-t/cm)
GM	7.20' (2.19 m)

* Refers to the length from the stem to the rudder post centerline.

† Distance athwartships over the catapults.

Actual GMs

King George V (After Refit, 1944)

7.40' (2.26 m) @ 44,460 tons (45,173 mt)

5.11' (1.56 m) @ 38,893 tons (39,517 mt)

Duke of York (After Refit, 1945)

7.19' (2.19 m) @ 44,790 tons (45,509 mt)

4.88' (1.49 m) @ 39,229 tons (39,859 mt)

Anson (After Refit, 1945)

7.20' (2.16 m) @ 45,360 tons (46,088 mt)

4.86' (1.48 m) @ 39,493 tons (40,127 mt)

Howe (After Refit, 1944)

7.25' (2.21 m) @ 44,510 tons (45,224 mt)

4.97' (1.51 m) @ 39,008 tons (39,634 mt)

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Armament

Ten 14-inch/45 caliber (Mark VII) (356 mm)

Sixteen 5.25-inch/50 caliber (Mark I) (134 mm)

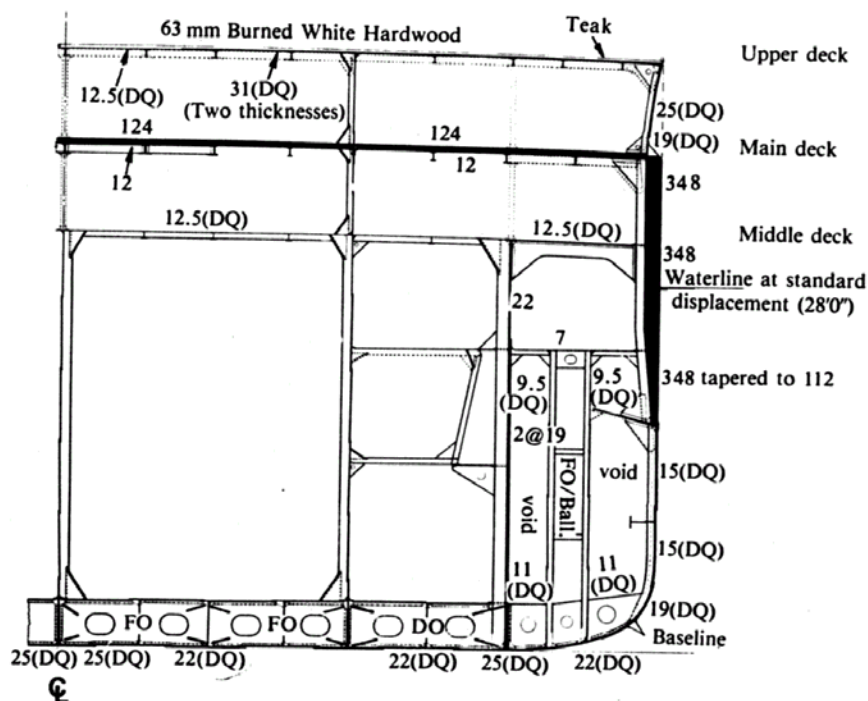
Machine-gun battery:

	Mk VI 8 Barrel 2-pdr.	Mk VII 4 Barrel 2-pdr.	U.S. Mk II 4 Barrel 40 mm	Mk III Single 40 mm	Mk V Twin 20 mm	Mk IIIA Single 20 mm	U.P.
<i>King George V</i>							
As built	4	none	none	none	none	none	4
Late 1941	5	none	none	none	none	2	none
Mid 1942	5	1	none	none	none	18	none
Early 1944	5	1	none	none	none	38	none
July 1944	8	none	2	none	6	26	none
Mid 1945	8	none	2	2	6	24	none
Late 1955			(All mountings removed)				
<i>Prince of Wales</i>							
As built	4	none	none	none	none	none	3
December 1941	6	none	none	1	none	8	none
<i>Duke of York</i>							
As built	6	none	none	none	none	10	none
Mid 1943	6	none	none	none	none	26	none
Early 1944	6	none	none	none	16	44	none
April 1945	8	6	2	none	8	38	none
Early 1948	8	2	none	none	8	none	none
Late 1955	8	2	none	6	2	none	none
<i>Anson</i>							
As built	6	none	none	none	none	10	none
Mid 1943	6	none	none	none	none	40	none
April 1945	8	4	2	none	6	15	none
Early 1946	8	4	2	none	6	34	none
Late 1955	8	2	none	none	6	4	none
<i>Howe</i>							
As built	6	none	none	none	none	18	none
Mid 1943	6	none	none	none	none	58	none
Mid 1944	8	none	2	none	4	34	none
Early 1946	8	6	2	20(?)	4	34(?)	none
Late 1955	8	none	none	6	4	none	none

Armor Protection

Immunity zone From 17,200 to 32,000 yards (15,728 to 29,261 m)—Magazines
 From 19,500 to 28,000 yards (17,831 to 25,603 m)—Machinery
 Against British 15"/42 gun (381 mm) firing 1938-lb (871 kg) shell.

Midship Section



Belt armor

magazines 14.71" (374 mm) tapered to 5.39" (137 mm) at lower edge of bottom strake.

machinery 13.73" (348 mm) tapered to 4.41" (112 mm) at lower edge of bottom strake.

Deck armor 4.90" (124 mm)—machinery; 5.88" (149 mm)—magazines.

Turret armor

face plates 12.75" (324 mm)

sides (gun chamber) 8.84" (224 mm)

(other) 6.86" (174 mm)

back plates 6.86" (174 mm)

roof plates 5.88" (149 mm)

Secondary gun armor

gun mounts 0.98" (25 mm)

magazines 0.98" (25 mm)

Barbette armor

centerline forward 11.76" (298 mm)

sides 12.75" (324 mm)

centerline aft 10.82" (275 mm)

Conning tower armor

centerline forward 3.94" (100 mm)

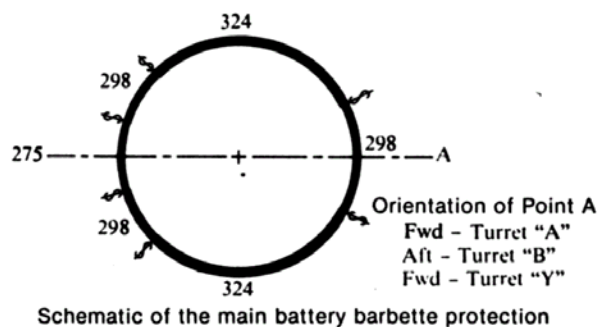
centerline aft 3.94" (100 mm)

beam sides 2.94" (75 mm)

roof plates 1.47" (38 mm)

bottom plate 1.47" (38 mm)

communication tube 0.98" (25 mm)



Schematic of the main battery barbette protection

Underwater Protection

Designed resistance 1,000 pounds (454 kg) of TNT

Side protective system depth 13' 0" @ half draft amidships

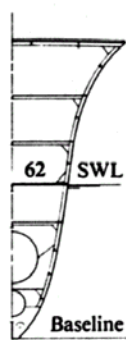
S.P.S. designed loading void-liquid-void

Total bulkhead thickness 2.25" (57 mm)

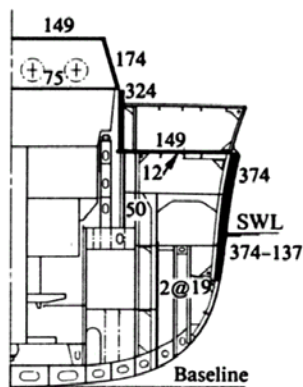
Bottom protective system depth amidships 4' 0" (1.219 m)

Total plating thickness 1.4375" (36 mm)

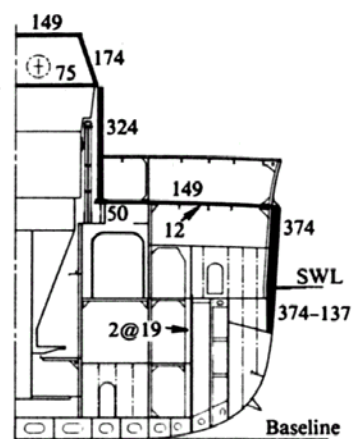
Frames



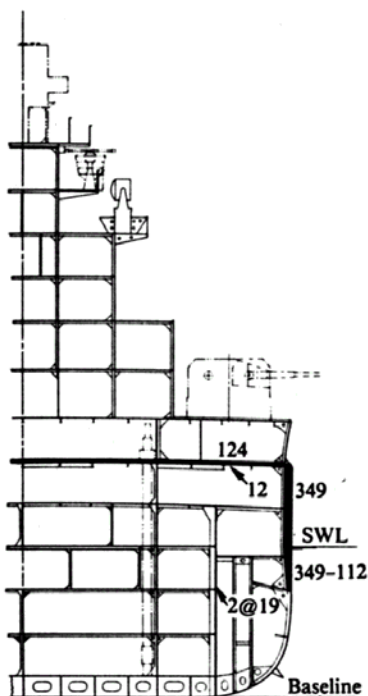
Frame 21



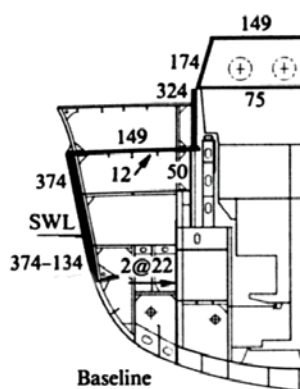
Frame 89 ("A" Barbette)



Frame 110 ("B" Barbette)



Frame 133 (Forward Boiler Room)



Frame 263 ("Y" Turret)



A.P. Frame 314

<i>Anson</i>	(1942)	27.62 knots at 113,000 shp (114,567 mhp) at displacement of 42,600 tons (43,284 mt)
<i>Howe</i>	(1942)	27.5 knots at 112,930 shp (114,496 mhp) at displacement of 42,530 tons (43,213 mt)
Nominal endurance		
<i>Anson</i>	(1946)	6,100 nautical miles at 10 knots 2,600 nautical miles at 27 knots
<i>Duke of York</i>	(1944)	5,600 nautical miles at 10 knots 2,400 nautical miles at 27 knots
Generators		
		six ship's service turbogenerators (330 kw) two diesel generators (330 kw) total ship's service capacity (2,640 kw)

Propellers four three-bladed manganese-bronze propellers of 14' 6"
(4.419 m) diameter

Rudder one

Miscellaneous

Complement

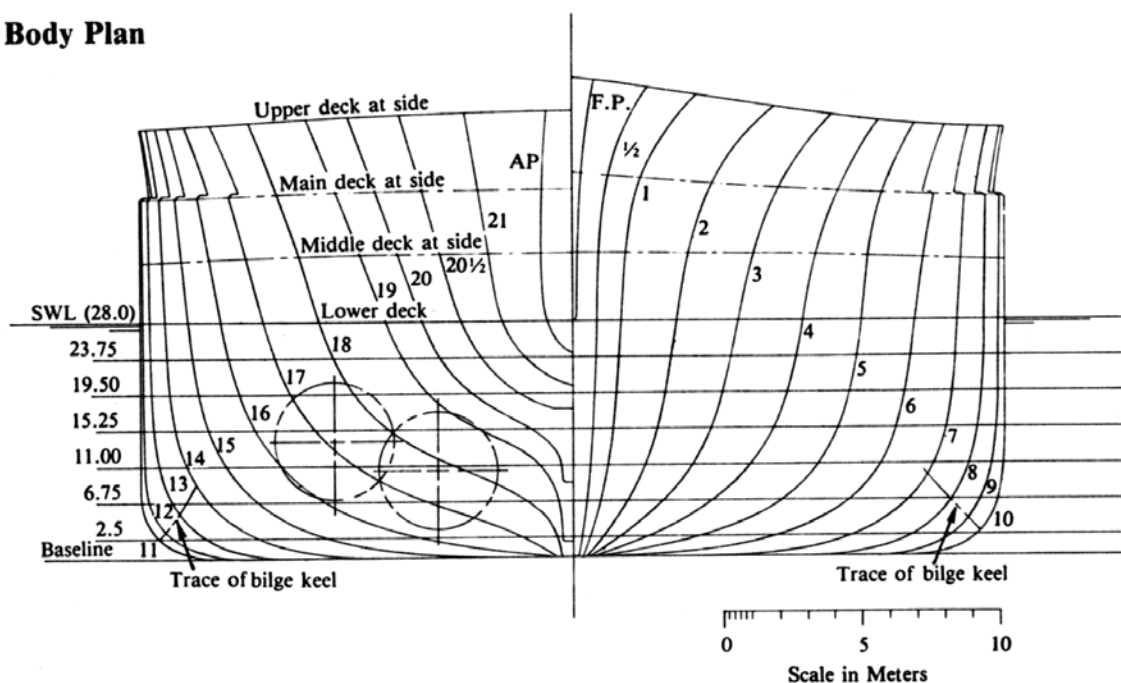
1,409 (70 off/1,339 enl)	design (1938)
1,543 (109 off/1,434 enl)	fleet flag ship (design 1938)
1,582	King George V (1944)
1,521	Prince of Wales (1941)
1,556	Duke of York (1945)
1,556	Anson (1945)
1,556	Howe (1945)

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Weights full complement and ammunition—(1940 King George V inclining experiment)

Hull	13,830 tons (14,052 mt)	36.4%
Outfit	1,619 tons (1,645 mt)	4.3%
Machinery	2,768 tons (2,812 mt)	7.3%
Armament	7,401 tons (7,520 mt)	19.5%
Armor & protection	12,413 tons (12,612 mt)	32.5%
Standard displacement	38,031 tons (38,641 mt)	100.0%
Reserve feed water	255 tons (259 mt)	
Lube oil	30 tons (30 mt)	
Gasoline	30 tons (30 mt)	
Water protection	107 tons (109 mt)	
Water in gasoline tank compartment	54 tons (55 mt)	
Fuel oil	3,730 tons (3,790 mt)	
Full load	42,237 tons (42,905 mt)	

Body Plan





CHAPTER SIX

Lion class

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With the design work of the *King George V* class completed and two of these ships under construction in 1937, attention was now drawn to the fact that Japan had not, and probably would not, sign the London Naval Treaty of 1936. This development permitted the main-battery caliber for new battleship construction to become 16-inches by 1 April 1937. The Admiralty was not enthusiastic about a 35,000-ton ship armed with such guns, however, as it believed a larger displacement would be required to produce a well-balanced design. There were many proposals made for 16-inch battleships that may or may not have been accepted. In fact, the notes concerning these preliminary proposals are a patchwork of information from which it is difficult to deduce the facts with complete confidence.

The first mention of a new battleship design was dated mid-1937, when the Director of Naval Construction, Sir Stanley Goodall, and his staff examined various design proposals, among which were:

- Eight (1×2 , 2×3) or nine (3×3) 16-inch guns in three turrets and eight 16-inch guns in four twin turrets.
- Reduction in the 5.25-inch battery to twelve guns.
- Armor protection to be based on the 15-inch/42-caliber guns.

As the preliminary design work progressed, it became evident that an all-triple mounting of the main battery would be required to simplify the ordering and to reduce the cost of production and design. Early sketch designs (16A and 16B—Table 6-2) of a ship armed with nine 16-inch guns indicated that the displacement would be greater than 36,000 tons, and severe measures would be required to reduce it to 35,500 tons—at which point further reductions might be possible through a rigorous weight-control effort. Some weight reduction was accomplished by reducing the width of the main side belt, decreasing the lengths of the main-battery magazines, and reducing the ammunition allowances in the standard displacement condition to sixty rounds per gun. All of these proposals substantially diminished the offensive and defensive qualities of the proposed new battleships; therefore, it became evident that a larger displacement would be required. Nonetheless, design work continued on 16A and 16B into early 1938.

In the meantime, the controller asked the Naval Construction Department to prepare a design with twelve 14-inch guns (14A) and a reduced 5.25-inch battery. This was probably requested because three more ships of the *King George V* design were to be ordered under the 1938 Program. Since there was much clamor about these ships' armament of ten 14-inch guns, it was felt that the reduction of the secondary battery gun power would permit two more barrels in the main armament than was possible in

The Lion class would have benefited from the experiences of the five battleships in the King George V class. The most modern of the King George V class was the Anson shown here at anchor in Victoria Harbor, Hong Kong, in September 1945. (Imperial War Museum)

the *King George V* and *Prince of Wales* then under construction. Moreover, the construction period of a battleship is largely influenced by the design, production, and testing of her main-battery turrets and guns, and 14-inch mountings would be available. It would not be necessary to wait for a new 16-inch-gun design.

By January 1938, it was clear that Japan was not going to sign the 1936 London Treaty, so the Admiralty decided to invoke the escalator clause of this treaty, which would permit battleships with a 45,000-ton standard displacement. On 31 March 1938 Great Britain, France, and the United States publicly declared their intentions in this regard. Prior to the announcement, the Admiralty had expressed the desire to raise the limit to only 40,000 tons and so advised the United States. The naval staff wanted a battleship armed with nine 16-inch guns, as it was believed that Japan was developing ships to be so armed. It was also recognized, based upon early preliminary designs, that a ship larger than a *King George V* would be required to mount such an armament. It was also desired, however, to restrict the displacement to 40,000 tons to avoid forcing other European powers to build larger ships that would outclass the *King George V* battleships in home waters. Some limitation in size was also sought for political and financial reasons.

Against this background, the staff requirements for the *Lion*-class battleships were drawn up in February 1938. No standard displacement was specified, since if both gun number and displacement had been specified, the designers would have had little latitude. Also noteworthy was that the armor protection would be based on the 16-inch gun, although no projectile weight was specified. The staff requirements as drawn up in February 1938 are summarized in Table 6-1.

TABLE 6-1

Lion Class Preliminary Designs

Main battery	Nine 16-inch (406-mm) guns
Secondary battery	Sixteen 5.25-inch (133-mm) guns—dual-purpose
Antiaircraft battery	Pom-poms to suit available space
Maximum speed	30 knots
Protection	
side armor	To resist 16-inch (406-mm) shell fired at a range of 14,000 yards (12,802 m).
deck armor	To resist 1,000-lb. (454-kg) armor-piercing bomb dropped from 15,000 feet (4,572 m), or a 16-inch (406-mm) shell fired from 30,000 yards (27,432 m). Protection over machinery to be less than that over magazines.
torpedo	To resist 1,000-lb. (454-kg) TNT charge in contact with side shell.

Intense preliminary design work during February and March 1938, based upon the staff requirements in Table 6-1, yielded schemes 16A-16G shown in Table 6-2. In addition, Designs 16A and 16B were updated to include the latest weight information from the two *King George V* battleships under construction. The most noteworthy aspect of the new design schemes was that there was no limitation on the standard displacement, allowing the designers to determine just how large a ship would have to be to satisfy all requirements.

Design 16C was a 35,000-ton type with increased splinter protection and a *King George V*-class propulsion plant. The reduced 5.25-inch battery offset the weight increases caused by the protective requirements.

Designs 16D-16G were larger designs based upon the February 1938 staff requirements and featured increased splinter protection. Design 16D had a 30-knot speed

TABLE 6-2

Preliminary Designs

Design Reference	14A-37	16A-38	16B-38	16C-38	
Date	December 1937	April 1938	April 1938	April 1938	
Displacement					
standard	35,450 (36,029)	35,540 (36,121)	35,640 (36,221)	35,500 (36,070)	
full load	...	41,400 (42,100)	41,500 (42,200)	...	
Dimensions					
waterline length	740 (226)	740 (226)	740 (226)	...	259
waterline beam	103 (31.5)	103 (31.5)	103 (31.5)	...	
draft	30.5 (9.30)	30.5 (9.30)	30.56 (9.31)	...	
Armament					
14-inch	12	none	none	9	
16-inch	none	9	9	3-3-A-3	
arrangement	4-4-A-4	3-3-A-3	3-3-A-3	8	
5.25-inch/50	12	12	12	32	
2-pdr pom-poms	32	32	32	8	
0.5" M/C guns	8	8	8	none	
torpedo tubes	none	none	none	4	
aircraft	none	none	none		
Protection					
belt					
amidships	13.73" (348)	13.73" (348)			
magazines	14.71" (374)	14.71" (374)		Same as 16A-38	
turret					
face	12.75" (324)	14.71" (374)	same as 16A-38		
sides	8.84" (224)	9.40" (213)			
rear	6.86" (174)	6.86" (174)			
decks					
amidships	4.90" (124)	4.90" (124)			
magazines	5.88" (149)	5.88" (149)			
Machinery					
shaft horsepower	120,000 (121,664)	100,000 (101,387)	120,000 (121,664)	100,000 (101,387)	
maximum speed	27	27	28.25	27.5	
endurance at 10 knots	14,000	14,000	14,000	...	
Weights					
outfit	1,050 (1,067)	1,050 (1,067)	1,020 (1,037)	...	
machinery	2,650 (2,693)	2,550 (2,592)	2,650 (2,693)	...	
armament	6,450 (6,555)	6,560 (6,667)	6,560 (6,667)	...	
armor protection	12,080 (12,278)	12,160 (12,359)	12,160 (12,359)	...	
hull	13,220 (13,436)	13,220 (13,436)	13,220 (13,436)	...	
standard displacement	35,450 (36,029)	35,540 (36,121)	35,640 (36,222)	...	
fuel oil	3,700 (3,759)	3,700 (3,759)	3,700 (3,759)	...	

with nine 16-inch guns and twelve 5.25-inch guns. It represented the limit to which a battleship could be designed by invoking the escalator clause of the 1936 London Treaty.

Design 16E represented a four-turret battleship favored by the Admiralty, even though these ships would be slower than the previous battleship class. To achieve 30 knots in this design, a standard displacement of greater than 50,000 tons would have been necessary. Since the horsepower (120,000) was the same as the other designs the speed was reduced accordingly. The design also resulted from a naval staff directive to ignore the docking restrictions of Rosyth and Portsmouth and design a ship with four

TABLE 6-2 (Continued)

260	Design reference	16D-38	16E-38	16F-38	16F-38 (Modified)
	Date	April 1938	April 1938	April 1938	June 1938
	Displacement				
	standard	42,500 (43,182)	48,500 (49,292)	39,500 (40,146)	40,750 (41,230 mt)
	full load	...	55,000 (55,898)	45,200 (45,938)	46,000 (46,740 mt)
	Dimensions				
	waterline length	...	820 (250 m)	770 (235 m)	780 (238 m)
	waterline beam	...	110 (33.5 m)	105 (30.6 m)	105 (30.6 m)
	draft	...	35.17 (10.72 m)	32.75 (9.98 m)	33.33 (10.16 m)
	Armament				
	16-inch/45	9	12	9	9
	arrangement	3-3-A-3	3-3-A-3-3	3-3-A-3	3-3-A-3
	5.25-inch/50	16	16	12	16
	2-pdr pom-pom	32	32	32	32
	0.5" M/C guns	8	8	8	8
	torpedo tubes	none	...	...	...
	aircraft	4	4	4	4
	Armor protection	Same as 16A-38 (except for splinter protection)			
	belt				
	amidships				
	magazines				
	turret				
	face				
	sides				
	rear				
	decks				
	amidships				
	magazines				
	Machinery				
	shaft horsepower	120,000 (121,664)	120,000	120,000	120,000*
	maximum speed	30	26	28.25	28.25
	endurance at 10 knots	...	14,000	14,000	14,000
	Weights				
	outfit	...	...	1,200 (1,220)	1,100 (1,120 mt)
	machinery	...	...	2,850 (2,897)	3,060 (3,110 mt)
	armament	...	...	6,250 (6,352)	6,940 (7,050 mt)
	armor protection	...	...	14,500 (14,737)	14,600 (14,830 mt)
	hull	...	...	14,700 (14,940)	15,050 (15,290 mt)
	standard displacement	...	...	39,500 (40,146)	40,750 (41,230 mt)
	fuel oil	...	4,400 (4,470)	4,000 (4,060)	4,000 (4,060 mt)

main-battery turrets. The extra beam was chosen to avoid exceeding a draft limitation of 31 feet.

Design 16F was the result of a displacement restriction of 40,000 tons by the controller on the basis of Admiralty intentions to invoke the treaty escalator clause. Therefore, it was shorter in length and had a smaller secondary battery than other designs of similar or larger displacement.

Design 16G featured a standard displacement of 43,000 tons with sixteen 5.25-inch guns and deck-mounted torpedo tubes. The torpedo tubes and extra two 5.25-inch mounts replaced the aircraft complement. The universal trend toward improved

TABLE 6-2 (Continued)

Design Reference	16G-38	14B-38
Date	April 1938	April 1938
Displacement		
standard	43,000 (43,690)	42,750 (43,448)
full load	49,000 (49,800)	48,500 (49,292)
Dimensions		
waterline length	850 (259)	820 (250)
waterline beam	...	106 (32.3)
draft	...	...
Armament		
16-inch/45	9	12 (14-inch)
arrangement	3-3-A-3	4-4-A-4
5.25-inch/50	16	16
2-pdr pom-pom	32	32
0.5" machine guns	8	8
torpedo tubes	8†	0
aircraft	4	4
Armor protection		
belt		
amidships		
magazines		
turrets		
face		
sides		
rear	Same as 16A-38	
decks		
amidships		
magazines		
Machinery		
shaft horsepower	150,000 (152,080)	150,000 (152,080)
maximum speed	30	30
endurance at 10 knots	14,000	14,000
Weights		
outfit	1,300 (1,321)	...
machinery	3,550 (3,608)	...
armament	7,200 (7,318)	...
armor protection	15,500 (15,753)	...
hull	15,900 (16,160)	...
standard displacement	43,000 (43,702)	42,750 (43,448)
fuel oil	4,400 (4,472)	4,400 (4,472)

* Turbines could be forced to 130,000 (overload) for short periods.

† Deck-mounted tubes in quadruple mounts.

armor protection, guns, and speed was evident in all schemes, with weight-saving techniques employed to permit the most powerful ship possible with a limited displacement. A significant point in the 1938 staff requirements for these designs was that radar (or RDF as it was known then) was included. The type of set was not specified, but it was presumably an early model of the Type 79Y air-search radar.

Design 14B was an interesting alternative and in a sense was a logical extension of Design 14A with a larger displacement. However, with the United States and probably Japan building battleships armed with 16-inch guns, this design had very few serious supporters.

At a meeting of the Sea Lords on 26 May 1938, it was finally decided to proceed with Design 16F, but to increase its standard displacement to 40,000 tons to permit a secondary battery of sixteen 5.25-inch guns, a side belt of uniform thickness, and slightly more powerful machinery. Drydock limitations were a matter of serious discussion during deliberations prior to this meeting. Clearances at the Portsmouth and Rosyth dockyards restricted the waterline beam to 106 feet and required a tapered form below the waterline; length restrictions of Devonport's reconstructed number 10 dock limited waterline length to 790 feet. If Portsmouth and Rosyth were eliminated from consideration, it was possible to increase the beam to 108 feet, the limit for ships using the Panama Canal. The design handicap posed by drydocking was fully recognized and drew this comment from the vice chief of the naval staff in 1940: "We must modernize our docking arrangements at home and not cripple our ship designs for the sake of two existing docks." But nothing was ever done to enlarge the docks, and in 1964 when the design of the attack aircraft carrier (CVA01) was completed, a new drydock was proposed to be built for her in Portsmouth. In 1938 there were a number of commercial and foreign docks able to handle ships with large beams in Southampton, Liverpool, Tilbury, Malta, Gibraltar, Singapore, Durban, Quebec, Esquimalt (British Columbia), and St. Johns (New Brunswick), plus several in the United States.

During June 1938, the final preliminary design work produced Design 16F (modified) shown in Table 6-2. By 15 July 1938, contract design commenced, and was completed by December 1938. Considerable discussion was given to the close-range armament during the contract phase of design. The naval staff wanted at least eight octuple pom-pom positions, but there was great difficulty in placing them free of blasts from the main and secondary gun positions. Eventually six were included.

Discussions on whether to carry aircraft were also held. It was recognized that carrier-borne aircraft would usually be available, but it was thought prudent to make provision for carrying two aircraft.

The changes made during the contract phase of the design, plus further weight information from the two battleships under construction, made it possible to reduce the standard displacement by 200 tons. These ships, compared with the *King George V* and *Nelson* classes, more effectively merged battleship and battlecruiser functions into a fast-battleship type. Many exterior features of the *King George V* class were retained, and the internal arrangement was almost a duplication of the design of that class.

On 15 December 1938 the Admiralty approved the design, and bids were solicited on the approved characteristics summarized in Table 6-3. Invitations to bid were solicited from the following:

Hull and machinery

John Brown, Clydebank; Fairfield, Glasgow;
Vickers Armstrongs, Barrow and Newcastle;
Cammell Laird, Birkenhead; Harland and Wolff, Belfast.

Hull only

Swan, Hunter, Wallsend

Machinery only

Wallsend Slipway; Parsons, Wallsend; Hawthorn, Leslie,
Newcastle; Scotts, Greenock.

Only a very short time was permitted for the bid preparations, even though it was during the holiday season. By 1 February 1939 all bids were received and the awards made on 21 February 1939. The short time between the acceptance of the design, the bidding, and the issuing of contracts resulted from the desire of the Admiralty to have these ships laid down as soon as possible.

TABLE 6-3

Lion Class, 1938 Contract Design Requirements

Standard displacement	40,550 tons (41,201 mt)
Full-load displacement	46,400 tons (47,145 mt)
Waterline length	780.0 feet (237.74 m)
Waterline beam	105.0 feet (32.0 m)
Draft (standard)	30.02 feet (9.15 m)
Armament	nine 16"/45 tripled (406 mm) sixteen 5.25"/50 twin (134 mm) forty-eight 2-pdr. pom-poms—octuple—(40 mm) two aircraft
Shaft horsepower	120,000 (121,664 mhp)—normal maximum 130,000 (131,803 mhp)—overload
Maximum speed	30 knots
Endurance	14,000 miles at 10 knots in trial condition
Fuel-oil capacity	3,720 tons (3,781 mt)
Main side belt	14.71" (374 mm) machinery/magazines
Protective deck	5.88" (148 mm) magazines 4.90" (124 mm) machinery

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Construction. Vickers Armstrongs and Cammell Laird were awarded contracts on 21 February 1939 to build one ship each. Delivery time was to be three and one-half years. The shipbuilders were responsible only for the hull and machinery, as the Admiralty provided the armament, armor, fire-control gear, aircraft equipment, and Admiralty pattern equipment. Two more ships were ordered from John Brown and Fairfield during the summer of 1939; they differed in the placement of the after control tower, which was shifted from "Y" turret to the after superstructure where it would be less affected by gun blast.

The first two ships of the class, the *Lion* and *Temeraire*, were ordered on 28 February 1939, under the 1938 estimates, for delivery in 1942. The *Conqueror* and *Thunderer* were authorized to be built in August 1939 under the 1939 estimates. The *Lion* (Yard number 16) was laid down at the Vickers Armstrongs yard at Walker, Newcastle-on-Tyne, on 4 July 1939. The *Temeraire* (Yard number 1045) was laid down on 1 June 1939 at the Cammell Laird yard at Birkenhead. The *Conqueror* was assigned to John Brown and Co., Clydebank, on 15 August 1939. With the approval of the chancellor of the exchequer, the construction of the *Thunderer*, although awarded to the Fairfield Shipbuilding and Engineering Co., Ltd., Glasgow, was never ordered. Construction of the *Lion* and *Temeraire* continued during the first two months of World War II, but not to any significant degree. In October 1939 construction of both ships was suspended for one year, and all steel work was left on the ways. The *Lion*'s 218-ton center girder was not removed from the ways until after the war.

1940 Design. Discussions continued during 1940 on a new design (16H-40), incorporating lessons learned in the war. The changes desired were a larger beam, better splinter protection for the secondary armament, more light antiaircraft machine guns with better arcs of fire, increased freeboard at the bow, and better endurance. On 12 November 1940, it was decided to further delay construction, but in February 1941 the First Sea Lord was anxious to resume the building. On 16 August 1941 Prime Minister Churchill inquired about the progress on the hull and also about the development of a 16-inch gun. He was told that shortages in labor and armor-making capacity were preventing the construction of the two ships.

Battleship-carrier. In October of 1940, the Director of Air Material proposed that a battleship hull under construction be completed as a battleship-aircraft carrier. A sketch was submitted to the design department for consideration. The concept was initially rejected, but subsequently revived in June 1941 when a *Lion*-class battleship hull was used as the basis for the design. The outstanding features of this design study were:

- Displacement at full load was approximately 51,000 tons, with a waterline length of 800 feet and a beam of 112 feet. The greater beam was desired for improved underwater protection and superior stability characteristics, as an offset for the greater topside weights characteristic of an aircraft carrier.
- The gun armament would have featured six 16-inch guns (tripled), sixteen 5.25-inch guns (paired), and six octuple pom-pom mounts.
- Twelve aircraft, two elevators, and a flight deck some 500 feet long by 73 feet wide were to be provided.

The design was submitted to the naval staff in July 1941, with a covering remark by Sir Stanley Goodall that the ship was neither good as a carrier nor good as a battleship. One of the major unresolved design problems was that of the protection of the uptakes.

The battleship-aircraft carrier design scheme was rejected by the naval staff, and no further work on such designs followed.

1941 Design. In late 1941 a redesign was commenced that would have reflected the *Bismarck* and *Ark Royal* experiences. With the entry of Japan into the war and the loss of the *Repulse* and *Prince of Wales* and overseas bases, the Royal Navy needed additional facilities and ships that could operate for long periods at great distances from those bases still in British possession. The entry of the United States into the conflict had strengthened Allied naval power, but there was the danger that the French Fleet would pass into the control of the Axis powers. Despite doubts about the value of battleships, they were still being sought in 1941 to give striking power to the fleets in all conditions of weather. So long as the Axis powers were building such ships, it was believed necessary to counter them.

During December 1941 and January 1942, intensive design work was accomplished on the *Lion*-class battleships to eliminate certain known weaknesses. The director of the Operations Division was particularly concerned about their endurance, stating in December 1941, "It is thought that the whole question of the endurance of these ships should be most carefully reviewed. There is no question that the endurance of the *King George V*-class ships has proved disappointing." Endurance consistent with operations in the Pacific was specified. The director of the Operations Division suggested these requirements: 100 hours at 25 knots with steam for full speed, 8 hours at 30 knots; 200 hours at 16 knots with steam for 20 knots, plus a 35 percent margin.

In January 1942, the redesign of the *Lion*-class battleships was completed; the final characteristics are tabulated in Table 6-4.

A comparison of these characteristics with those in Table 6-3 shows four important differences, the most notable being the changes in the beam and side-armor protection. The loss of the *Prince of Wales* proved that the underwater protection of the *King George V*-class battleships had to be improved at all costs. This also meant rearranging the spaces over the side protection system, as well as making some changes in the compartmentation of the vitals. The most notable deficiency was in the transverse depth of the side protection system. This was overcome by increasing the beam to 108 feet making these ships wall-sided yet still able to transit the Panama Canal, although an even larger beam was preferred. To accomplish this change with-

TABLE 6-4

1942 Contract Design Requirements

Standard displacement	42,550 tons (43,233 mt)
Full-load displacement	47,650 tons (48,415 mt)
Waterline length	780.0 feet (238 m)
Waterline beam	108.0 feet (32.92 m)
Draft (standard)	30.17 feet (9.20 m)
Armament	nine 16"/45 tripled (406 mm) sixteen 5.25"/50 twin (134 mm) seventy-two 2-pdr. pom-poms octupled (40 mm)
Shaft horsepower	120,000 (121,664 mhp)—maximum 130,000 (131,803 mhp)—overload
Maximum speed	28.25 knots
Endurance	16,500 nautical miles at the 10-knot trial condition.
Fuel-oil capacity	4,800 tons (4,877 mt)
Main side belt	
Machinery	13.73 inches (349 mm)
Magazines	14.71 inches (374 mm)
Deck protection	
Machinery	4.90 inches (124 mm)
Magazines	5.88 inches (149 mm)

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out resorting to large displacements, the side armor was reduced a full inch in thickness except over the most vulnerable portion of the magazines. Another important difference was an increase in the designed endurance from 14,000 to 16,500 nautical miles, as these ships had to operate for longer periods at sea. The pursuit of the *Bismarck* demonstrated the need for an improvement in the endurances of British battleships, as the German ship almost escaped because of the low levels of fuel in the *Prince of Wales*, *King George V*, and *Rodney*. Due to the need for a more concentrated and numerous light antiaircraft battery, the number of pom-poms was increased from 48 to 76. The aircraft and catapults were to be removed as a weight compensation and space provision.

The 1941-42 operations of the *King George V* and *Prince of Wales* had convinced the Ship Design Department that these new British battleships had insufficient freeboard forward. The Board of the Admiralty concurred, and rescinded the requirement that "A" turret be able to fire at zero-degree elevation. The bow profile was changed to increase the freeboard from 28.25 to 37.0 feet.

The redesign also added more radar equipment and splinter protection. The most extensive modification, however, took place in the electric plant, since the loss of the *Prince of Wales* had shown that the ring-main system and the group changeover switches were less than ideal. Better communications were also to be provided between the electrical generator compartments to prevent the type of casualty that occurred in the stern area of the *Prince of Wales* after the first torpedo hits.

Material and labor shortages still prevented work on the *Lion* and *Temeraire*. Production of heavy gun mounts was necessary for coastal defense guns, armor plate was required for tank production, and shipyard labor was required for aircraft carrier and merchant-ship construction. The naval staff was anxious for the construction of the battleships to resume as quickly as possible, but it was never authorized. Emphasis on battleships waned when Pacific operations showed that the aircraft carrier was more versatile. When British battleship strength increased to fifteen with the completion of the *Anson* and *Howe*, the naval staff postponed the construction of the *Lion* and *Temeraire* in 1943 in favor of the building as many as fifty-five to sixty-two aircraft carriers. (Included among these was the *Gibraltar*-class carrier, which was

comparable in size to the American *Midway*-class carrier.) There was little likelihood of completing these battleships within the anticipated duration of the war. Therefore, Vickers Armstrongs was requested to remove the 218 tons of steel from the slipway, and the armor plates already rolled were shipped to Shrewburyness for proof-testing of projectiles.

1944 Design. In 1944, on the instructions of Sir Stanley Goodall, the *Lion*-class design was reexamined and new sketches made to embody war experiences. It was determined, however, that the power of modern weapons had increased so much that ever-increasing armor and torpedo protection was required until it became incompatible with the limited offensive power of the ship. It was clear that the weights of the principal items would increase, and thus the first essential task was to try to make the citadel more compact to reduce the armor weight. The long and vulnerable shafts were cause for concern as proved by the torpedo damage to the *Prince of Wales*.

At this stage the underwater protection system was not studied, nor were the final characteristics settled. It was recognized, however, that torpedo charges had become more powerful and that a wider system would probably be necessary.* The study was not officially sanctioned, but Sir Stanley Goodall proceeded with it, understanding that the battleship class might be a possible candidate for future discussion. He probably took the reasonable precaution of being prepared to contribute some views based on war experiences.

Further design work ceased, and the incomplete keels of the two battleships had been removed from the slipways by May 1945.

Armament. Characteristics of the guns mounted on these ships are shown in Table 6-5.

Main battery. As compared with the Mark I guns on the *Nelson* and *Rodney*, the 16-inch/45-caliber guns projected for the *Lion* class were much improved, as is shown in Table 6-6.

Three models of 16-inch guns were developed for the *Lion*-class design. The Mark II and Mark III 16-inch/45-caliber guns were virtually identical, differing only in structural details of the breech. A total of twenty-eight of these guns were actually ordered, and five guns (three Mark II and two Mark III) were completed. The guns were primarily designed for accuracy and regularity of the muzzle velocity, not for particularly outstanding ballistic performance.

The projectiles, which weighed 2,375 pounds, were limited to an overall length of 73 inches by the mounting design, which was developed along the general lines of the *King George V* 14-inch turrets.

* Raven and Roberts in their book, *British Battleships of World War II*, indicate that a sketch of a body plan of a 56,500-ton *Lion* with a 115-foot beam was prepared "early in the war." The authors believe this sketch study was more likely related to the 1944 design studies. Based upon early design studies and characteristics of the final 1942 redesign, the 1944 *Lion* for this displacement would have had the following:

Length—830' (253.0 m)

Beam—115' (35.05 m)

Draft— 35' (10.67 m)

These dimensions are purely speculative, but would reflect increased length for speed and propulsive efficiency. The larger displacement would also support the increase in armor and underwater protection, in addition to larger main-battery turrets.

TABLE 6-5

Gun Characteristics

Gun	16" (406 mm)/45	5.25" (133 mm)/50	"2-pounder"*
Shell weight (lbs.)	2,375 (1,077 kg)	80 (36.3 kg)	1.81 (0.82 kg)
Muzzle velocity (fps)	2,450 (747 mps)	2,600 (792 mps)	2,300 (701 mps)
Maximum range (yds)	43,800 (40,500 m)	23,400 (21,400 m)	5,000 (4,572 m)
Maximum elevation	40°	70°	80°

* 1.594"/40 (40.5 mm)

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TABLE 6-6

Comparison of 16-inch Guns—Nelson and Lion

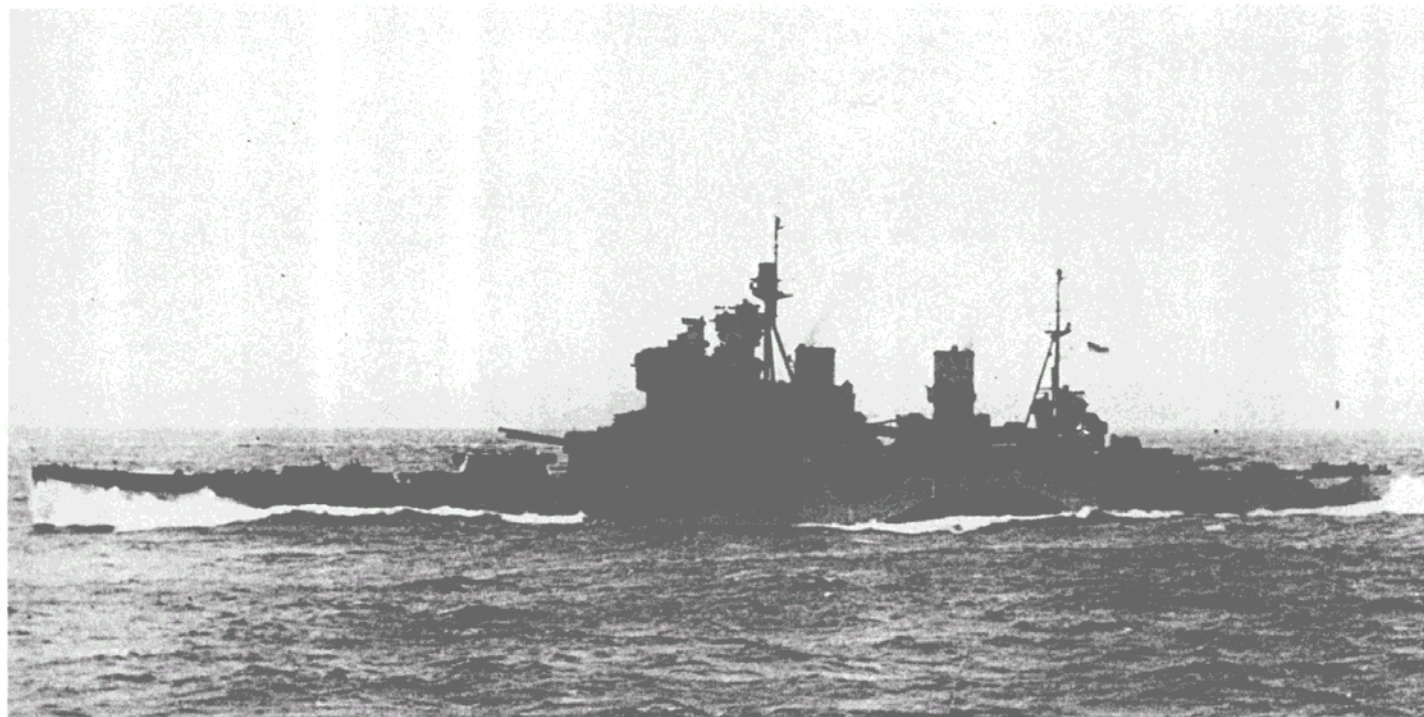
Gun	16-inch/45 Mark I	16-inch/45 Mark II
Ship	<i>Nelson</i>	<i>Lion</i>
Shell weight (lbs)	2,048 (929 kg)	2,375 (1,080 kg)
Muzzle velocity (fps)	2,525 (770 mps)	2,450 (747 mps)
Range at 40° elev. (yds)	35,800 (32,736 m)	43,800 (40,051 m)
Armor penetration—vertical		
15,000 yd. (13,716 m)	14.4" (366 mm)	17.7" (449 mm)
20,000 yd. (18,288 m)	12.2" (310 mm)	15.3" (389 mm)
25,000 yd. (22,860 m)	10.3" (261 mm)	13.2" (335 mm)
30,000 yd. (27,432 m)	8.8" (224 mm)	11.5" (292 mm)
35,000 yd. (32,004 m)	7.6" (193 mm)	10.1" (257 mm)
Armor penetration—horizontal		
15,000 yd. (13,716 m)	1.95" (49 mm)	2.22" (36 mm)
20,000 yd. (18,288 m)	2.85" (72 mm)	3.24" (82 mm)
25,000 yd. (22,860 m)	3.9" (99 mm)	4.41" (112 mm)
30,000 yd. (27,432 m)	5.1" (130 mm)	5.73" (143 mm)
35,000 yd. (32,004 m)	6.5" (165 mm)	7.25" (184 mm)

The redesign of the *Lion* near the end of the war prompted the development of a new 16-inch/45-caliber gun design (Mark IV). The gun was to be designed to use flashless powder, with a minimum muzzle velocity of 2,450 feet per second. The turret design was to be modified to accommodate projectiles with an overall length of 78 inches, which length was to determine the shell weight. The new shell for the Mark IV 16-inch gun has been estimated to have a weight of approximately 2,540 pounds. The Mark IV gun never progressed beyond the design stage.

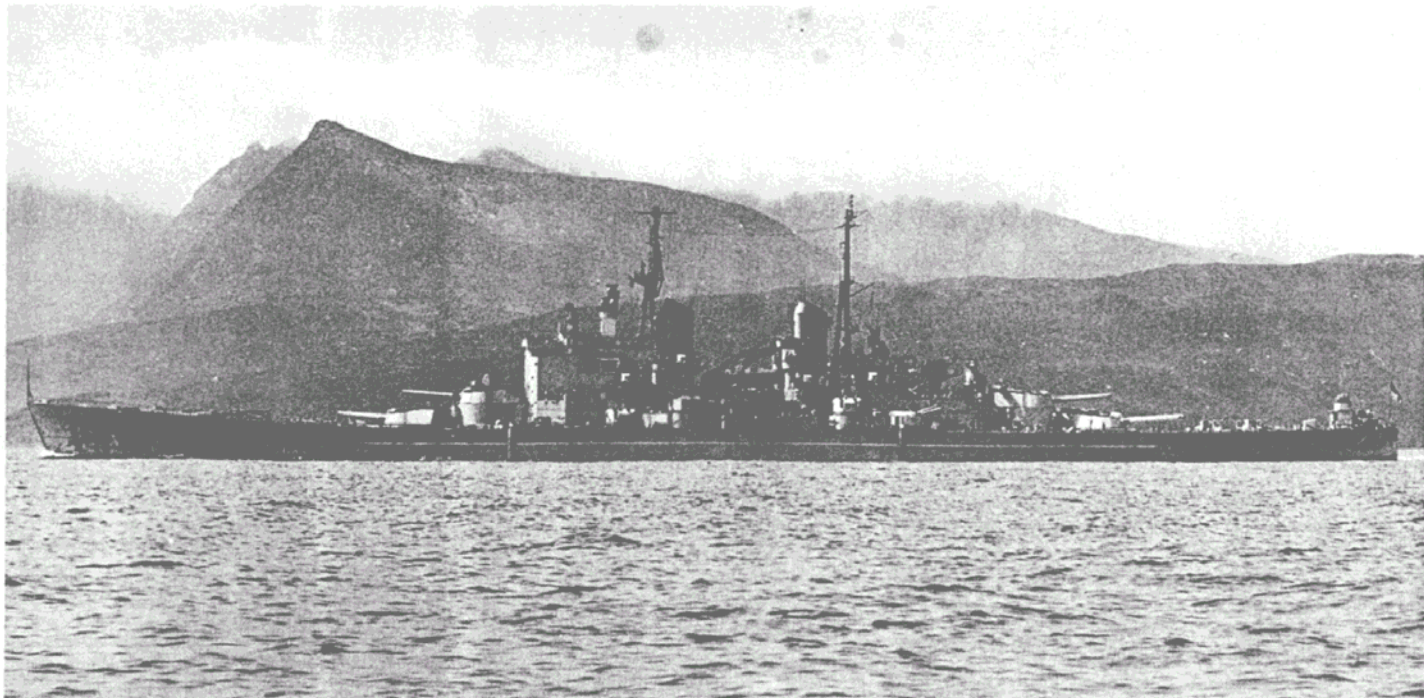
It was typical of the trend in modern naval guns that the newer models fired a heavier shell at a reduced muzzle velocity, which improved the performance at long ranges and prolonged the barrel life.

Secondary battery. The secondary battery consisted of sixteen dual-purpose 5.25-inch/50-caliber guns in eight twin mounts, identical to those fitted on the *King George V*-class battleships.

Antiaircraft battery. Short-range antiaircraft protection was the subject of considerable discussion. During contract design, the naval staff wanted at least eight Mk VI octuple pom-pom mounts, but there was great difficulty in placing them clear of the blast of the 16-inch and 5.25-inch guns, despite the larger beam and length of the new ships. Only six mounts were accommodated in Design 16F (modified), but in January 1942 the design was reworked and the aircraft complement was deleted. This per-



The Lion class were similar to the basic general arrangement of the King George V class with two main-battery turrets forward and one aft. The gun caliber, however, was 16-inch and the displacement 42,000 tons standard. The secondary and antiaircraft batteries were identical. Shown here is the Howe steaming at high speeds during her trials.



The Lion class would have resembled the HMS Vanguard, shown here, more closely than any of the King George V class in appearance with the exception of the number of main-battery turrets. Like the Lion design, the Vanguard featured the transom stern and rakish bow. (Scottish National Archives)

mitted a total of four additional mounts to be placed (three Mark VI, octuples, and one Mark VII, quad), with one mount fitted on "B" turret. The 0.5-inch machine-gun battery specified in earlier designs was eliminated, as it was of limited value in ship defense against aircraft. The U.P. projectors were given first consideration as a replacement, but after the loss of the *Hood* these weapons were no longer thought to be a viable weapon and were removed from the *King George V* and *Prince of Wales* during subsequent shipyard availability periods after the sinking of the *Bismarck*. The pom-poms would probably have been supplanted by the superior 40-mm Bofors machine gun before the *Lion* and *Temeraire* were completed. These ships had more space for such guns; if they had been completed, they would have mounted a more powerful armament than any other Royal Navy battleship.

Torpedo tubes. During the early phases of design, it was proposed that these ships carry 21-inch torpedo tubes in two deck-mounted quadruple launchers. Since the *Lion*-class battleships had greater available deck area and displacement than the *King George V*-class, it was thought that such an armament might be a further defense against night attack—a distinct possibility in the days before radar. When the *Hood* was lost in May 1941, it was first thought that her loaded deck-mounted torpedo tubes may have been struck by shellfire and the torpedoes exploded. Adequate protection would have required thick armor plate high in the ship, clearly out of the question when weight control was so important and the use of such a weapon was so doubtful. Although the torpedo tube requirement still appeared in the 1942 ship characteristics, it was definitely an item to be eliminated with the advent of radar.

Aircraft. From the conception of the design, a requirement for spotting aircraft was maintained, as it was thought prudent to make provision for them even though carrier aircraft would usually be available. In the final design (December 1938) the number of aircraft was cut from four to two. Early war experiences were to later prove the worth of aircraft carriers, and it was clear, after the *Prince of Wales* and *Repulse* were sunk, that battleships would no longer act independently of aircraft carriers. In the *Lion*-class redesign of 1942, all aircraft facilities were eliminated.

Protection. The protective systems were designed to conform to three basic requirements: to resist the effects of 16-inch shellfire, a 1,000-pound TNT charge exploding in contact with the ship's side, and a 1,000-pound armor-piercing bomb dropped from an altitude of 15,000 feet. Detailed studies of the armor-piercing capabilities of the projected 16-inch guns were used in the design of the armor for the *Lion*-class battleships, since it was assumed that Japan was building ships so armed. Distances for penetration, using a 2,375-pound shell, are tabulated in Table 6-7.

The requirements for improved armor protection dictated that it exceed that provided for the *King George V* class. As a consequence, almost 40 percent of the 4,000-ton increase in the standard displacement was directly attributable to improved armor protection.

The vertical main side belt, 14.71 inches thick, extended along the entire expanse of the armored citadel. The main side belt was 15 feet wide with only 6 inches below the 30-foot waterline before it began to taper. This involved a significant change from the previous class, in which armor shielding the magazines was one-inch thicker than that protecting the machinery. Since these ships were no longer limited to the 35,000-ton standard displacement, it was possible to provide more local protection. The lower side belt tapered from 14.71 inches to 5.18 inches over a vertical distance of

TABLE 6-7

Armor Penetration—16-inch, 2,375-Pound Shell

	Target Angle	Penetration Range
14.71-inch (374-mm) belt	60°	14,000 yards (12,802m)
	70°	16,400 yards (14,996m)
13.73-inch (349-mm) belt	60°	16,000 yards (14,630m)
	70°	18,600 yards (17,008m)
5.88-inch (149-mm) deck	all	28,500 yards (26,060m)

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8.25 feet, extending 433 feet from the forward to the after armored bulkhead. This lower belt was extended 40 feet beyond the armored bulkheads, with the same vertical span as at amidships. The thicknesses at the top strake tapered from 14.71 to 10.79 inches at the end of the lower side belt; the lower edge remained constantly 5.58 inches thick. The lower side belt was 510 feet long, some 65 percent of the waterline length. The main side belt was effective against 16-inch shellfire at a range of approximately 19,000 yards.

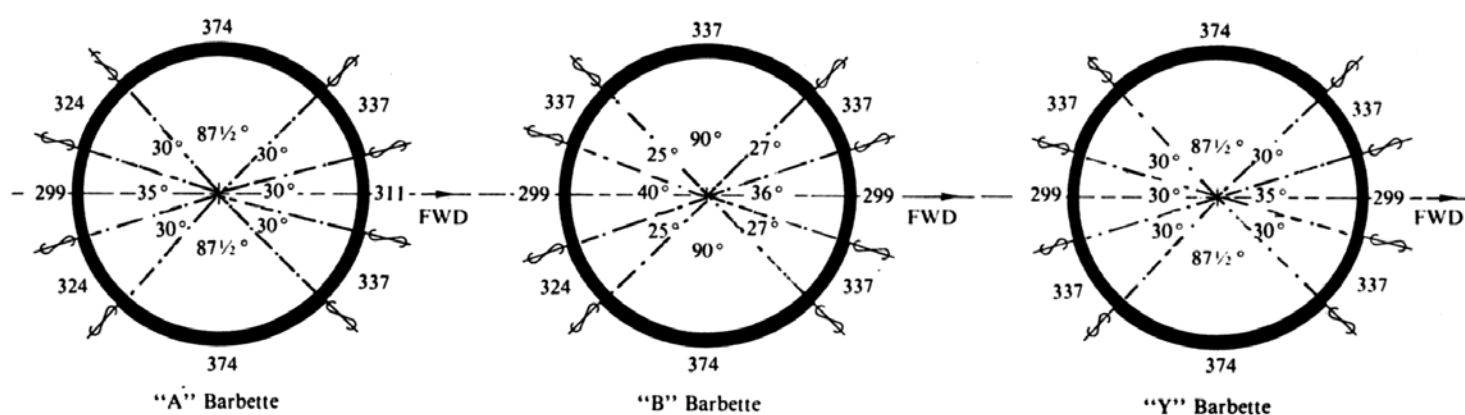
Deck armor. Horizontal protection was designed to withstand bomb attack, although concurrent attention was given to protection against long-range shellfire. The main-deck armor thickness was identical to that in the *King George V* class—5.88 inches over the magazines and 4.90 inches over the propulsion plant. Added splinter protection was provided for the magazines. Noncemented armor 1.47 to 1.96 inches thick was used over and around all the magazines. An armored deck (the lower deck) provided limited protection forward and aft of the armored bulkheads. Forward, this deck was 4.90 inches thick at the armored bulkhead and tapered to 2.45 inches at its terminus, 24 feet from the stem. Aft, it was 4.90 inches thick at the armored bulkhead and tapered to 4.41 inches over the shafts and steering-gear room. The armor deck aft was knuckled outboard to provide added protection, since no belt armor was provided over the steering-gear room. Protection beyond the citadel was intended to prevent the loss of buoyancy or ship control due to splinter damage. By causing bombs to explode on or near this deck, it was hoped to reduce damage to equipment and spaces below.

Conning tower. The Board of the Admiralty had slightly amended its original opinions regarding conning tower and bridge protection, although very heavy armor for these areas was still absent. The design requirements were to resist the 5-inch shellfire of destroyers.

Armored bulkheads. There were three armored bulkheads in the *Lion* class. The forward and after armored bulkheads had heavy armor protection. Class A armor of 9.81 inches was used between the torpedo bulkheads and increased to 11.77 inches on the beam segment. Below the lower armor deck, the thickness decreased to 1.98 inches of Class B armor. Such a reduced thickness was possible because the bulkhead and armor deck were to have worked in concert against a shell striking forward of the main-battery magazines. A third armored bulkhead was provided abaft the steering-gear room and consisted of 3.92 inch noncemented armor.

Turret armor. The main-battery turrets had slightly less armor than those on the *Nelson*-class ships. The armor thicknesses used, however, were considered adequate against bombs and shells of the period.

Except that the armor protection was graded as shown in figure 6-1, barbette protection was similar to that used on the *Nelson* and *Rodney*. Armor was thickest



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Figure 6-1. Main-Battery Barbette Protection (Note: This is a simple plan view of barbette.)

on the beam segment, where damage was more likely, and thinner towards the centerline. The barbette armor provided "B" turret was heavier, a consequence of its greater exposure to shellfire than either "A" or "Y" turrets. Below the armor deck, thicknesses were reduced because of the protection provided by the armor deck and the main side belt.

Protection of the secondary mounts was improved as compared to the *King George V*-class ships, although it remained only adequate against shell splinters and fragments, and was not adequate against direct hits. It was thought that heavy protection for these mounts would detract excessively from other features, especially stability, while providing only marginal improvement in overall protection.

There was more splinter protection in these battleships than in the previous class. The forward superstructure was to be provided with 0.5-inch protection. The supports for the director, the cable trunks above the main deck, and the communications tube to the conning tower were provided with 1.96 inch noncemented armor. Uptakes in the superstructure and above the lower armor deck were provided with 0.96-inch noncemented armor protection against shell and bomb-fragment attack.

Side protection. The arrangement and scantlings of the underwater side protection system were similar to those used in the *King George V* class. The major differences were the breadth of the system at the half-draft condition, the type of steel employed in the shell plating and stiffeners, and the heavier side armor belt necessary to resist 16-inch shells. Unfortunately, some design deficiencies in the earlier ships were retained. The system on the earlier battleship class had been designed to resist a 1,000-pound TNT charge, but displacement restrictions and limitations on beam and draft did not permit the optimum breadth in the torpedo defense system some naval constructors felt was necessary.

Beam was dictated by the requirements of the propulsion plant and the dockyard limitations at Portsmouth and Rosyth. Although the torpedo bulkhead had been moved inboard as far as the volumetric requirements of the propulsion plant would permit, and localized protection was provided where possible, the depths employed were little changed relative to those of the *King George V* class, as the data in Table 6-8 indicate.

"D" quality steel with an ultimate tensile strength of 37 to 44 tons per square inch was used in these ships, as in the Job-74 mockup and the *King George V* class. In the vicinity of the after main turret, where the beam rapidly diminished and the shafts emerged through the side protection system, it was necessary to step the torpedo

TABLE 6-8
Characteristics of Side Protection System

<i>Location</i>	<i>Depth at Half Draft</i>	<i>Total Bulkhead Thickness</i>	<i>Torpedo Bulkhead</i>
"A" Turret	11.00' (3.35 m)	2.50" (64 mm)	2×0.875" (2×22 mm)
"B" Turret	14.25' (4.34 m)	2.50" (64 mm)	2×0.875" (2×22 mm)
Amidships	13.25' (4.03 m)	2.50" (64 mm)	2×0.875" (2×22 mm)
"Y" Turret	13.00' (3.96 m)	2.50" (64 mm)	2×0.875" (2×22 mm)

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bulkhead 6.5 feet inboard to provide torpedo protection for "Y" turret's magazines. The stepping-in of the torpedo bulkhead also provided some structural continuity for the shaft alley bulkheads for the wing shafts.

Underbottom protection. The *Lion*-class battleships had a simple double bottom four feet deep. Experiments had led to the conclusion that no form of bottom protection could be devised that would prevent the effect of a near-miss bomb or noncontact torpedo explosion from doing considerable damage inside the ship. Bulkheads were specially designed with the object of restricting the amount of flooding that would result. For this reason, boiler and engine rooms were separated, so that not more than two units would likely be lost from a single hit.

Subdivision and Stability. The *Lion*-class battleships were to have been divided into twenty main watertight compartments by transverse bulkheads that extended to the upper deck. The only main watertight bulkhead not extending to this deck was one just forward of the forward armored bulkhead. The torpedo bulkhead formed the inner boundary of twenty-four watertight wing compartments per side in the vicinity of the side protection system. Based upon the analysis of torpedo damage to the *Prince of Wales* and the close liaison established between the U.S. Navy's Bureau of Ships and the Admiralty's Ship Design Division in late 1941, the arrangement of this system would have changed. This relationship probably would have changed the manner in which the side compartments were subdivided and the outboard structural arrangement of the main watertight bulkheads in the side protection system.

Royal Navy practice required that the metacentric height of battleships should be between six and eight feet. The only available data for the metacentric heights (no free-surface corrections) of the *Lion*-class battleships are tabulated in Table 6-9.

TABLE 6-9
Stability Requirements

<i>Condition</i>	<i>Displacement</i>	<i>Draft</i>	<i>GM</i>
Full load	46,875 tons (47,617 mt)	33.75' (10.29 m)	8.30' (2.52 m)
½ Fuel	42,400 tons (43,081 mt)	31.00' (9.45 m)	7.17' (2.19 m)
Standard	40,610 tons (41,262 mt)	29.92' (9.12 m)	6.00' (1.83 m)

Radar. The design of the *Lion* class as completed in 1938 was influenced by the electronics development which preceded World War II. The 1938 staff requirements specified radar, or radio direction finders—probably the same equipment installed in the *King George V* or the *Prince of Wales* in 1940-41. The reworked design of February 1942 provided for equipment similar to that provided at that date for the HMS *Vanguard*.

Propulsion Plant. The increase in the displacement, resulting from additional armament and protection requirements, necessitated a greater shaft horsepower to provide the same speed as the *King George V* class, despite the fact that these ships would be 45 feet longer (i.e., have a better speed to length ratio). Speed and power capabilities are tabulated in Table 6-10.

TABLE 6-10

Speed and Power Summary

Displacement	Shaft Horsepower (Normal)	Speed	Overload (Max. Rated Power)	Speed
40,550 (41,200 mt)	120,000 (121,664)	29.25	130,000 (130,801)	30.75
46,400 (47,100 mt)	120,000 (121,664)	28.25	130,000 (130,801)	28.75

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The near 30-knot speed, the 16-inch guns, and the heavy displacement would have made these battleships the fastest and most powerful the United Kingdom ever built, although the battlecruiser *Hood* might have had a slight edge in speed and displacement.

It was planned that the boilers could be forced to 130,000 shaft horsepower for long periods, and piping and turbine designs were based on that figure. In the event greater overload power could be achieved, 130,000 would have become the normal maximum power.

The Royal Navy was determined to meet the universal trend to higher speed in its new battleships. All foreign types then in design or under construction had speeds of at least 27 knots, and in several types the maximum speed exceeded 30 knots. The *Lion*-class battleships would have had Parsons geared turbines with single reduction helical gears. With a working pressure of 350 psi and a temperature of 700°F, the turbine unit would have consisted of high and low pressure, astern, and cruising turbines.

Each boiler room contained two boilers of the three-drum small-tube type with a common stokehold under forced draft. The working pressure was to have been 400 psi at a temperature of 700°F.

The arrangement of the propulsion plant was similar to that used in the previous battleship class and was intended to limit flooding from underbottom damage. Although the machinery was in four units (one fireroom and one engine room) which worked separately in service, the engine and firerooms were fitted with cross connections for routine and emergency use.

Electric plant. Electrical power in the original design was produced by six turbogenerators and two diesel generators supplying 220-volt direct current to the ring main. This system was identical to that of the *King George V* ships, including the group changeover switches that proved so unsuccessful in the *Prince of Wales*. In 1938, the director of electrical engineering issued a paper setting forth requirements for the electric plants of ships of cruiser size or larger. It was decided that all ships of the 1938 Program would use steam-driven generators, since they were considered more reliable, took up less space, and weighed less than diesel generators. The heavy cruiser *Belfast* sustained a total loss of steam when she exploded a magnetic mine, and it was decided that the proportion of diesel to steam generators should be increased. The final arrangement was two diesel generators forward of the forward machinery rooms and two abreast of the after engine rooms, while two turbogenerators were abreast of

the forward boiler rooms and two were in the auxiliary machinery room between the two forward engine rooms. Although it was undesirable to locate generators adjacent to the torpedo bulkhead, it was difficult to locate them elsewhere.

Hull Characteristics. The hull form, much like that of a cruiser, was a new and interesting development. The square or transom stern carried well below the waterline was a distinguishing feature, adopted primarily to improve speed at higher ranges, although it required more material for fabrication. By extending the transom below the waterline, the ship would always have her stern immersed, resulting in better water flow to the propellers. The resistance benefit of the "square-cut stern" at high speeds for cruiser and battleship hull forms was apparent from model-test results in the early twenties, but the configuration was not applied until the *Fiji*-class cruisers were built in the thirties. Because the dimensional limitations resulted in a hull form with a higher prismatic coefficient, the effective horsepower was greater than that projected for the *Tiger* or *King George V* hulls. A bulbous bow tested in a model tank was found to give better results at high speed than at cruising speeds, but was not adopted.

Docking problems resulted in the adoption of a novel underwater hull form amidships in the 1938 design. The shell was sloped outboard five degrees, eliminating the wall-sided appearance of the *King George V* class. The waterline beam was 105 feet, which tapered to 100 feet at the keel level to eliminate any interference in docking. An increase in beam was necessary for protection requirements, but this sloping side shell could not provide the depth in the side protection system that a wall-sided section would have yielded. Naval constructors were aware of this, but a larger beam would have prevented accommodating these ships in two major dockyards. This restriction was later lifted in the 1942 redesign, when it became apparent from the war experience of the *Prince of Wales* that the docking restrictions at Portsmouth and Rosyth were crippling British capital-ship design in regard to providing an underwater protection system of sufficient depth.

Sheer. The sheer profile was the same as in the previous British battleship class, so that "A" turret could fire directly ahead at zero elevation. In the final design, the freeboard at the bow was increased to 37 feet. The obsolete requirement on the sheer profile would have probably produced the same poor seakeeping qualities as it did in the *King George Vs* and *Nelsons*. More freeboard at the bow would have alleviated this problem, but at the price of limiting the firing arcs for "A" turret at low elevations, as happened later when the *Vanguard* was so modified. There is no doubt that the freeboard of these ships would have also been gradually reduced during refits, due to an increase in anti-aircraft armament and electronic equipment, additional complement, and changes in compartmentation, pumping, and ventilation, following the loss of the *Prince of Wales*. Certainly the engagement between the *Hood*, *Prince of Wales*, and *Bismarck* would have antedated the completion of the first ship of this class, and there would have been a change in the bow profile for better seakeeping.

Summary. The design of the *Lion*-class battleships would have corrected some of the deficiencies existing in the *King George V* battleships. Two notable shortcomings still existed in the 1938 design: first, greater emphasis should have been placed on the development of a deeper torpedo-defense system, even at the expense of

altering shipyard facilities. The lack of sufficient breadth in the side protection system was partially corrected in the 1942 design by increasing the beam to 108 feet. Canal restrictions prevented an even wider system, which was being sought by naval constructors following the torpedoing of the *Prince of Wales*. However, because of the shaft arrangement, the stepped torpedo bulkhead outboard of "Y" turret was retained. Continuity of heavily stressed structure should have been mandatory; discontinuities can cause severe stress concentrations that might lead to the eventual failure of vital structure. Only a larger beam, with a consequent relaxation of the docking restrictions, could have corrected these faults and provided sufficient protection to the magazines where the hull breadth decreased. The docking restrictions were the severest handicap in the design of these ships, and an adequate underwater protection system had long eluded naval constructors. In testimony before the Bucknill Committee that investigated the loss of the *Prince of Wales*, Sir Stanley Goodall, the director of naval construction, quoted this extract from a report made after World War I:

In order that the construction department of the Admiralty may be in a position to produce the best designs for new capital ships, we strongly recommend that the limitations as to beam which have hitherto handicapped us be removed to the fullest possible extent.

The loss of the *Prince of Wales* also revealed a weakness in the original torpedo protection of the *Lion* class. The spaces over the torpedo protection system should not have been used for ship purposes, and the torpedo bulkheads should have been carried one deck higher. This was accomplished in the 1942 design by eliminating the washrooms over the torpedo defense system and eventually revising the general arrangement of the ship. The deletion of the aircraft made the hangars available for increased complement.

A second weakness in the 1938 design was the endurance of these ships. Originally, the endurance was to be the same as that of the *King George V* class, although the fuel capacity in the *Lions* would have been slightly increased. This increase, however, was not adequate if the same design procedures were followed, as was done in the previous battleship class. The deficient endurance was improved in the 1942 design, after experience with the *Prince of Wales* and *King George V* had been evaluated. To accomplish this, the fuel capacity was increased approximately 1,100 tons in the 1942 design.

The main armament would have been the most powerful in the Royal Navy and would have been better distributed than that in the *Nelson* and *Rodney*, resulting in the elimination of the blast problem. The 16-inch guns were not the most powerful in the world, but their design stressed consistency in salvos—no substantial loss of muzzle velocity due to barrel erosion. Winston Churchill, even before he became prime minister, favored the construction of these ships, even if it meant the cancellation of the last three *King George V* battleships in the 1938 Naval Program. However, high costs and limited shipyard facilities, combined with the Admiralty emphasis on carrier construction in 1942, brought about the cancellation of the construction of what would have been the most powerful and fastest battleships to have served in the Royal Navy.

Name	<i>Lion</i>	<i>Temeraire</i>
Builder	Vickers Armstrongs, Ltd., Walker on Tyne	Cammell Laird & Co., Ltd., Birkenhead
Laid Down	4 July 1939 (Yard No. 16)	1 June 1939
Launched	...	...
Disposition	Canceled in 1942. Scrapped	Postponed in 1940. Scrapped
Name	<i>Conqueror</i>	<i>Thunderer</i>
Builder	John Brown & Co., Ltd., Clydebank	Fairfield Shipbuilding and Engineering Co., Ltd.
Disposition	Canceled in 1942	Never officially ordered.

Displacement

(1942) 42,550 tons (43,233 mt)—Standard
 (1942) 47,650 tons (48,415 mt)—Full Load

Dimensions

793' 0" (241.706 meters) Length overall
 780' 0" (237.744 meters) Waterline length
 740' 0" (225.552 meters) Length between perpendiculars
 108' 0" (32.918 meters) Waterline beam (maximum)
 52' 9" (16.078 meters) Depth at side
 34' 3" (10.439 meters) Draft at 47,650 tons (48,415 mt)

Hull Characteristics at D.W.L.

Displacement	42,550 tons (43,233 mt)
Mean draft	30' 2" (9.195 m)
Freeboard at bow	37' 0" (11.278 m)
Freeboard at stern	24' 7" (7.493 m)
Frame spacing (armor box)	2' 0" (0.610 m)
(ends)	3' 0" (0.914 m)
Block coefficient	0.545
Prismatic coefficient	0.551
Midship section coefficient	0.990

Armament

Nine 16-inch/45-caliber guns (Mark IV) (406 mm)
 Sixteen 5.25-inch/50-caliber guns (Mark I) (133 mm)
 Antiaircraft machine guns seventy-six 2-pdr pom-poms in *nine* octuple mounts and one quadruple mount.

Armor Protection

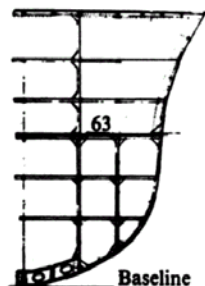
Immunity zone 19,000 to 30,625 yards (18,288 to 28,004 m)—Magazines
 22,000 to 27,250 yards (20,117 to 24,918 m)—Machinery
 against 16"/45-caliber gun (406 mm) firing 2,375-pound (1,077 kg) shell.

Barbette armor

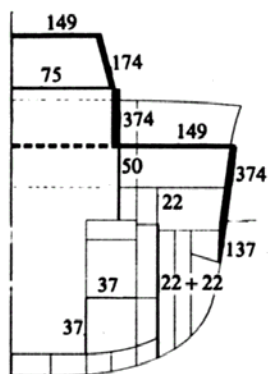
Centerline forward 11.76" (300 mm)
 Sides 14.71" (373 mm)
 Centerline aft 11.76" (300 mm)
 Turret has 12.24" (311 mm) on after end

Note: All armor data based on 1942 design.

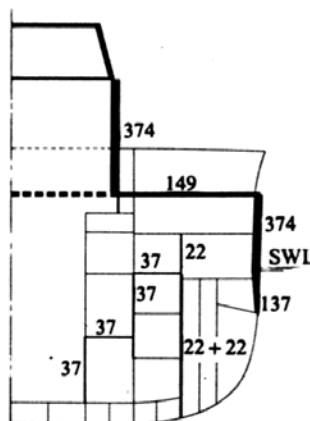
Frames



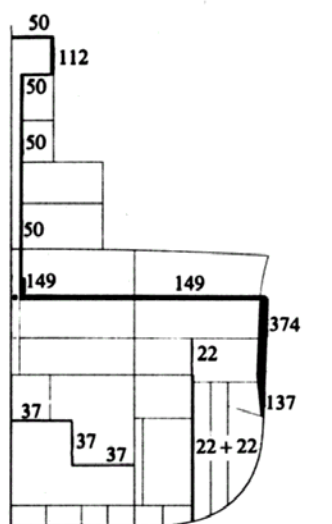
Forward Section
Frame 63



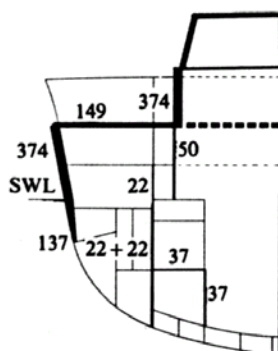
Center of "A" Barbette



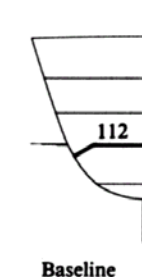
Center of "B" Barbette



Center of Conning Tower



Center of "Y" Barbette



Section at AP
steering gear room

Turret armor

- Face plates 14.71" (373 mm)
- Sides (gun chamber) 9.84" (250 mm)
- (other) 5.88" (149 mm)
- Back plate 6.86" (224 mm)
- Roof plates 5.88" (149 mm)

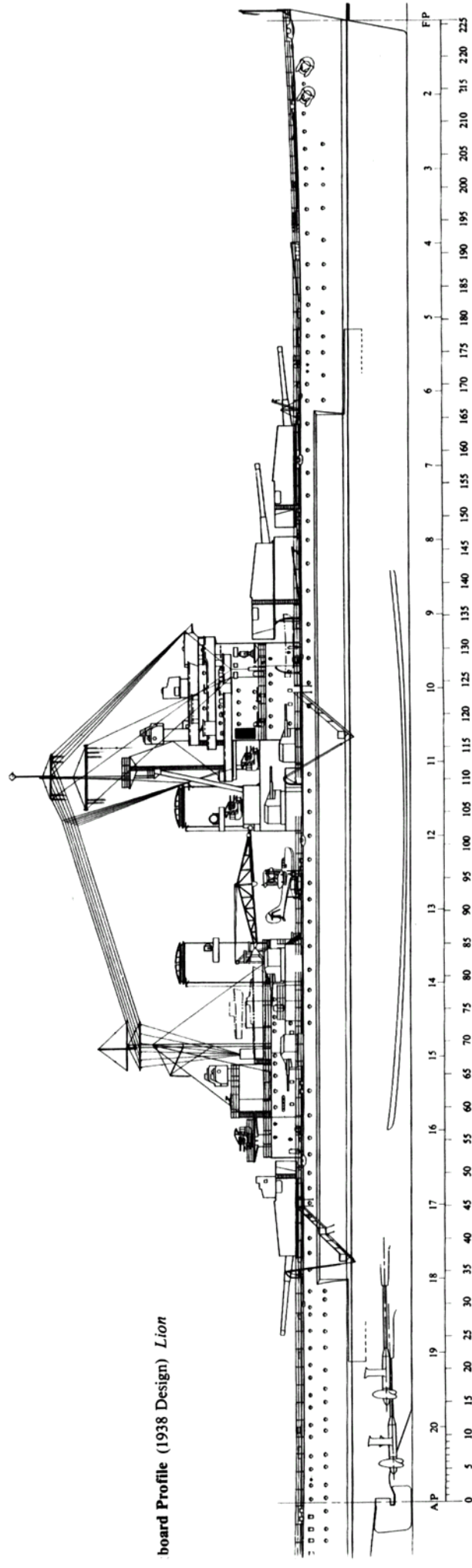
Secondary gun armor

- Handling rooms 1.47" (38 mm) sides
- 0.98" (25 mm) roof

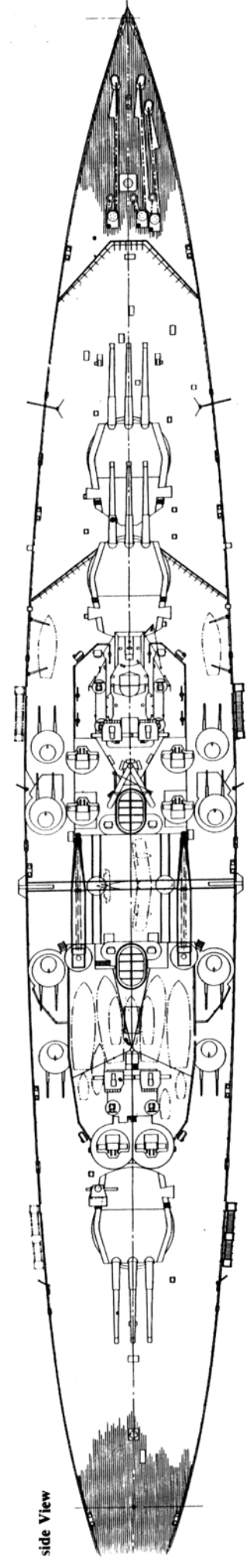
Conning tower armor

- Centerline forward 2.94" (75 mm)
- Centerline aft 2.94" (75 mm)
- Beam sides 4.31" (110 mm)
- Roof plates 1.96" (50 mm)
- Bottom plates 1.96" (50 mm)
- Communications tube 1.96" (50 mm)

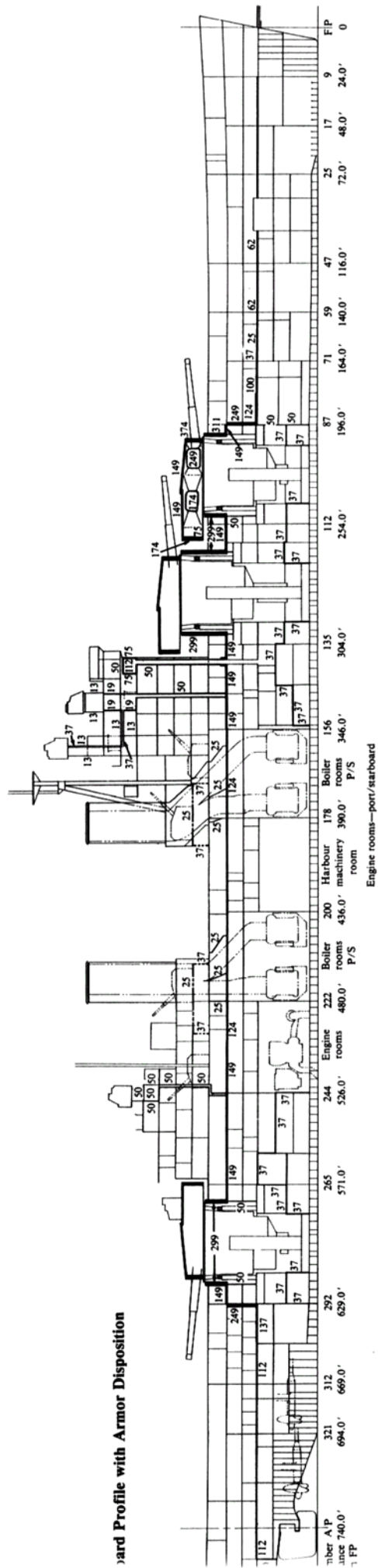
board Profile (1938 Design) *Lion*



side View

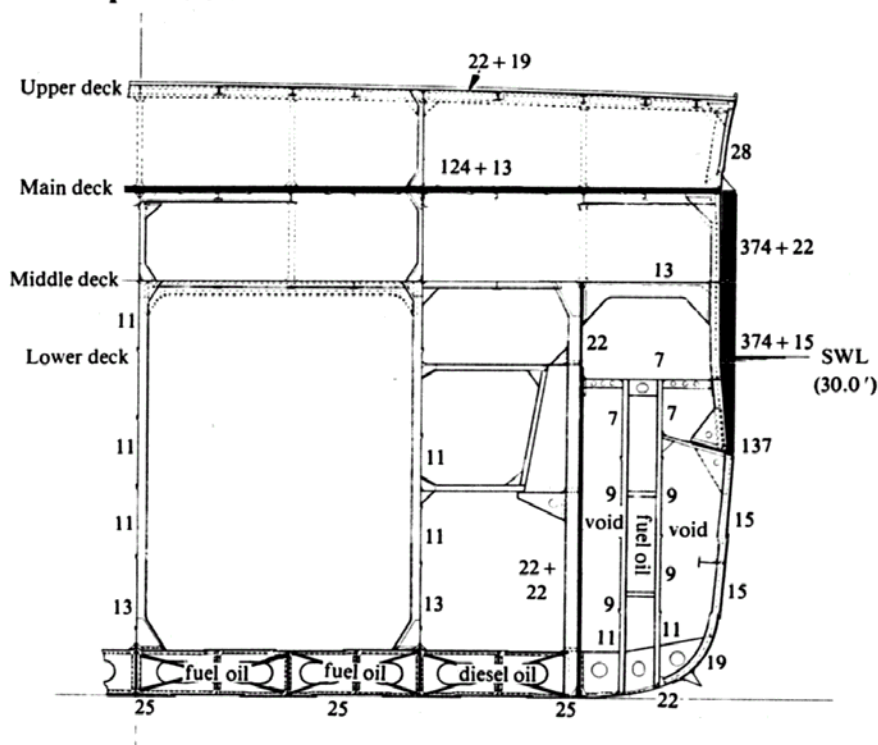


ard Profile with Armor Disposition

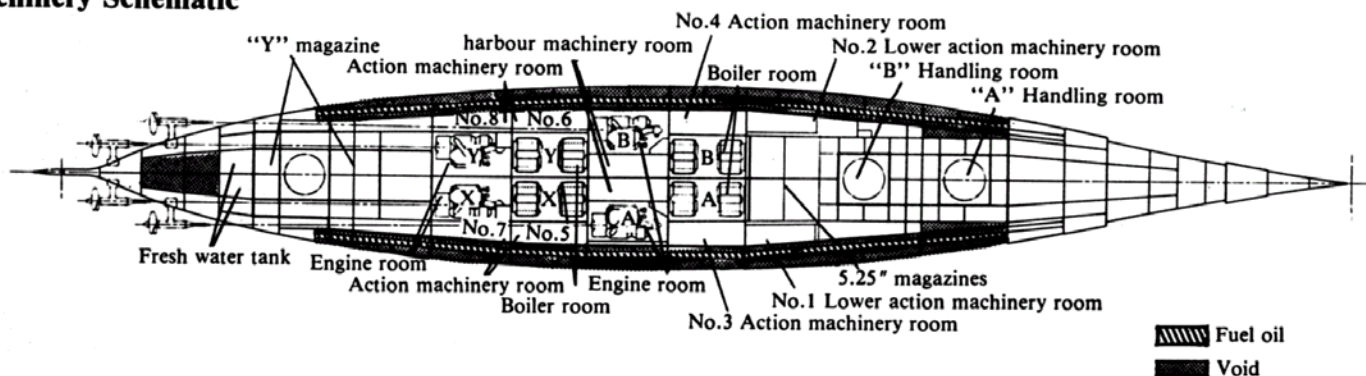


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Midship Section



Machinery Schematic



Underwater Protection

Designed resistance 1,000 pounds (454 kg) of TNT
 Side protection system depth 15.00 feet (4.57 m) at half draft amidships
 S.P.S. designed loading void-liquid-void
 Total bulkhead thickness 2.47" (63 mm)
 Bottom protective system depth 4.0 feet (1.219 m)—one layer

Machinery

Boilers eight Admiralty three-drum small-tube type with common furnace under forced draft.
 Turbines four sets of Parsons-type turbines with single reduction gear.
 Shaft horsepower 120,000 shp (121,664 mhp) normal
 130,000 shp (130,801 mhp) overload

Maximum speed 28.25 knots at a displacement of 47,650 tons (48,415)
 Generators four turbogenerators rated at 330kw
 four diesel generators rated at 330kw
 Propellers four
 Rudders one (balanced type)

Miscellaneous

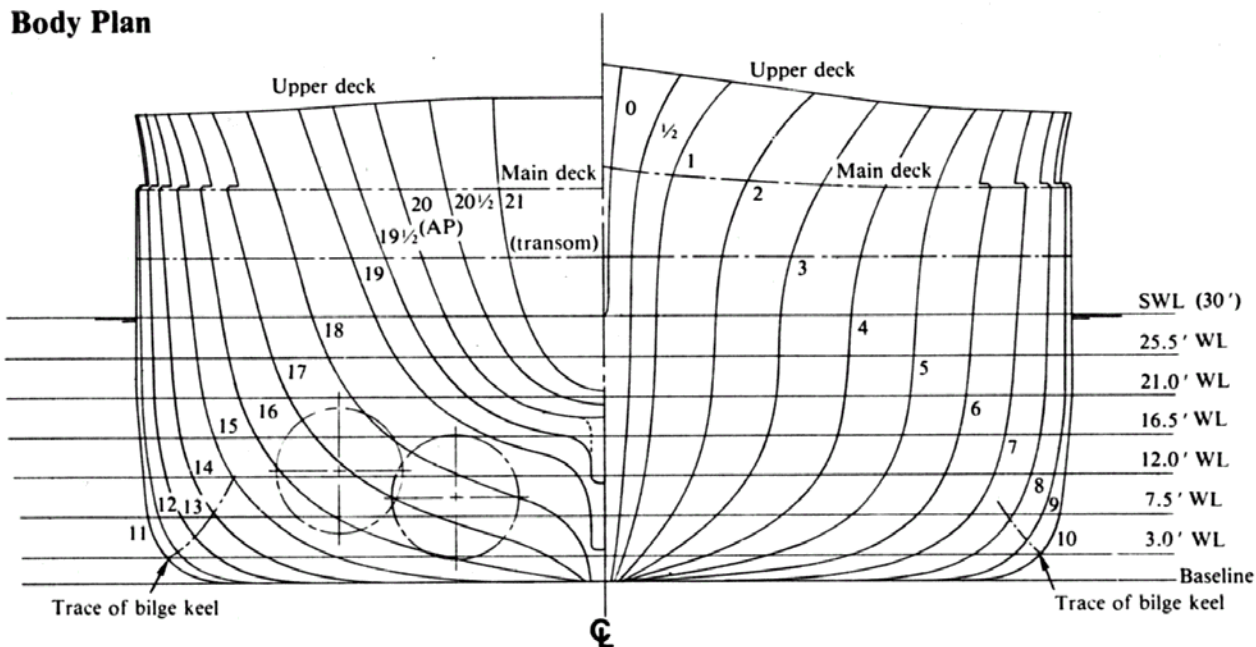
Complement 1,750 (officers and enlisted)—design (1942)

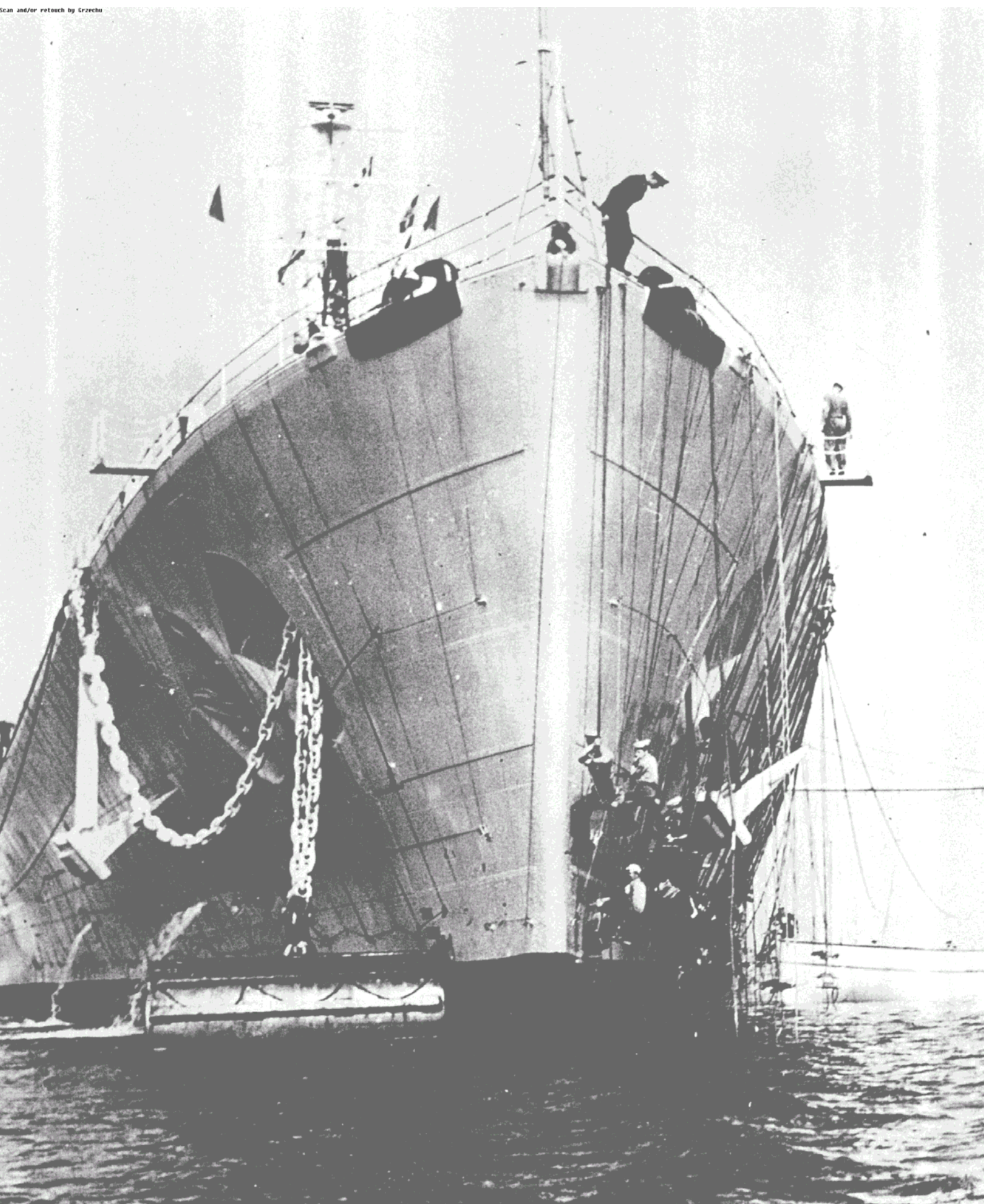
Weights

Hull	15,650 tons (15,901 mt)—36.9%
Outfit	1,100 tons (1,118 mt)—2.5%
Machinery	3,200 tons (3,251 mt)—7.5%
Armament	7,900 tons (8,027 mt)—18.5%
Armor and protection	14,700 tons (14,936 mt)—34.6%
Standard displacement	42,550 tons (43,233 mt)—100%

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Body Plan





CHAPTER SEVEN

The Vanguard

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The inception of the *Vanguard* design occurred in March 1939 when Sir Stanley Goodall, the director of naval construction, proposed that the spare 15-inch/42-caliber guns and turrets held in reserve for the ships of the *Queen Elizabeth* and *Revenge* classes be used as the basis for a new battleship design. He pointed out in his presentation of the concept that the time required to design and build main-battery guns and turrets determined the construction time for a battleship, and that as all European navies favored the 15-inch gun, his proposal would eliminate the testing and development of a new gun model. The turrets could be modified and mounted on a hull with *King George V* standards of protection and a *Lion* class propulsion plant. The endurance would be based on that proposed for the *King George V* class.

Sir Stanley Goodall's proposal was carefully reviewed by the Plans Division and was finally submitted to the naval staff for further consideration. Several factors were highly influential in a decision to prepare a design which would ultimately result in the HMS *Vanguard*.

- Great Britain would have to deploy part of its battle fleet to the Far East in numbers that would be less than those of the Japanese.
- Germany was completing those ships allotted to her under the 1935 Anglo-German naval accord, and more battleships were on order (six battleships of the "H" class were in the contract plans stage).
- A certain number of British capital ships would be undergoing repairs. British intelligence had also determined that Japan was preparing to build two 32,000-ton battlecruisers armed with 12-inch guns and designed for high speed.

It was recognized that the *Lion* and *Temeraire* would not be ready until 1943 at the earliest, and a fast battleship could be used in the Far East just as soon as possible. British battlecruisers had to be deployed in home waters to guard against the armored ships and the *Gneisenau* and *Scharnhorst*. The controlling factor was the gun mountings, and there were four turrets available. The standard displacement was recommended to be 40,000 tons with the speed and protection of a *Lion*-class battleship. A second ship could be constructed by using the 15-inch guns and turrets from *Revenge*-class battleships, which would reach their overage limit in 1942.

The naval staff was very pleased with the concept, and it authorized the director of naval construction to develop a ship design with the requirements tabulated in Table 7-1.

Three schemes (Table 7-2) were drawn up and submitted to the Board of the Admiralty on 17 July 1939:

The Vanguard was the flagship of the Coronation Naval Review in 1953, when Queen Elizabeth succeeded her late father, King George VI. The crew is busily engaged in readying the battleship for her role. (Imperial War Museum)

TABLE 7-1
Basic Characteristics

Dimensions	
Beam*	Maximum of 105 feet (32.00 m)
Draft†	Maximum of 34 feet (10.36 m)
Armament	Eight 15"/42-caliber (381-mm) guns in four turrets Sixteen 5.25"/50-caliber (133-mm) guns in eight mounts Forty-eight 2-pdr Mark VI pom-poms in six octuple mounts Two aircraft
Speed	Between 27 and 31.5 knots
Protection	Vertical—to resist 15" 1,938-lb/(889-kg) shell fired at range of 14,000 yards (12,802 m). Horizontal—to resist 1,000-lb. (454-kg) armor-piercing shell dropped from 14,000 feet (4,267 meters). Underwater—to resist 1,000-lb TNT charge exploded against side shell.

* To permit docking at Rosyth and Portsmouth.

† To allow a minimum of 3.25 feet under the keel in the Suez Canal.

- 15A—an enlarged *King George V* with four turrets.
- 15B—a fast *King George V* with four turrets.
- 15C—a *Lion*-class propulsion plant and four twin turrets.

In discussions on the three designs, it was finally concluded that Design 15C was the most advantageous, although Design 15B was preferred. The basic reason why Design 15C was chosen was the time element—the machinery-plant design of the *Lion* class had been completed, while 15B would require a completely new design. Major considerations in the early designs were speed and power, docking requirements, and protection, which influenced the hull form, dimensions, and arrangements. At first the hull was contoured to conform to the dock entrances at Portsmouth and Rosyth, with the side shell brought inboard as in the early *Lion*-class designs. The ship arrangement was basically similar to that of the *King George V* and *Lion* classes, but with four turrets instead of three. The Board of the Admiralty preferred this, even with a slight reduction in speed.

When the war began in September 1939, design work on the *Vanguard* stopped, to be resumed again in February 1940. In the meantime, construction of the *Lion* and *Temeraire* had been suspended, and the *Conqueror* and *Thunderer* were canceled, clearing the way for construction of a new battleship in the 1940 Program. In a letter dated 3 December 1939, the First Lord of the Admiralty, Winston Churchill, wrote:

I was much interested in the Director of Naval Construction's remark about the possibility of making a new battleship with the four 15-inch gun turrets. Such a vessel would be of the battleship-cruiser type, heavily armored and absolutely proof against air attack. Pray let me have a legend with estimates of money and time. This ship could come in after the *King George V* batch are finished and before *Lion* and *Temeraire*.

In February 1940 design work was resumed, and a new design, 15D, (Table 7-2) was completed. It included splinter protection forward and aft of the armored citadel from the lower to the middle decks and on the 5.25-inch mounts, and a small conning tower was to be provided aft. Discussions on the proposed redesign in February 1940 indicated that the 5.25-inch mount protection was insufficient against a 500-pound semi-armor-piercing bomb. It was agreed that the protection of these mounts would be increased (2-inch sides and 3-inch roof), but at the expense of the splinter belt (3 inches to 2.5 inches). Four UP mountings were to supplement the six pom-pom mounts. The

TABLE 7-2
Preliminary Designs, HMS Vanguard

Design	15-A	15-B	15-C	15-D
Date	July 1939	July 1939	July 1939	Feb. 1940
Displacement				
standard	38,000 tons (38,610 mt)	40,000 (40,642)	40,000 (40,642)	41,200 (41,861)
full load		45,400 (46,128)	45,400 (46,128)	47,000 (48,754)
Dimensions				
waterline length	770' (234.70 m)	800' (243.84)	800' (243.84)	800' (243.84)
waterline beam	104' (31.70)	105' (32.00)	105' (32.00)	105' 6" (32.16)
full-load draft	32' 6" (9.91)	33' 3" (10.13)	33' 3" (10.13)	33' 6" (10.21)
Armament				
15"/42* (paired)	8	8	8	8
5.25"/50 (paired)	16	16	16	16
2-pdr. pom-pom	48	48	48	48
UP mountings	...	...	...	4
floatplanes	2	2	2	2
Armor				
belt				
magazines	14.71" (374)	14.71" (374)	14.71" (374)	14.71"-13.73" (374-348)
amidships	13.73" (348)	13.73" (348)	13.73" (348)	13.73" (348)
turrets				
face	12.75" (324)	12.75" (324)	12.75" (324)	12.75" (324)
sides	8.82" (224)	8.82" (224)	8.82" (224)	8.82" (224)
rear	6.86" (174)	6.86" (174)	6.86" (174)	6.86" (174)
splinter protection	1.47" (37)	1.47" (37)	1.47" (37)	1.47" (37)
decks				
magazines	5.88" (149)	5.88" (149)	5.88" (149)	5.88" (149)
amidships	4.90" (124)	4.90" (124)	4.90" (124)	4.90" (124)
Machinery				
shaft horsepower	100,000 (101,387)	130,000 (131,803)	120,000 (121,664)	120,000 (121,664)
maximum speed†	28.5 knots	30.25 knots	29.75 knots	29.5 knots
endurance @ 10 knots	14,000 n. mi.	14,000 n. mi.	14,000 n. mi.	14,000 n. mi.
fuel oil	3,700 (3,759)	3,700 (3,759)	3,700 (3,759)	3,800 (3,861)

* All designs, two twin turrets forward, two aft.

† Based on standard displacement.

design was approved on 20 May 1940 by the First Lord of the Admiralty as the best means for Great Britain to augment her battleship force during the expected duration of the war. Parliament also favored the new battleship design, as it reduced development costs and construction time.

Design work was suspended from May through October 1940. When it resumed, John Brown and Company, Ltd., of Clydebank provided personnel to speed up the work and regain some of the lost time. While the work continued, more design changes were made as a result of recent combat experience, including increased fuel-oil capacity, short-range antiaircraft weapons (pom-poms), and better armor protection. These changes so increased the draft beyond the 34-foot limit required for passage through the Suez Canal that it was necessary to increase the beam to 108 feet, preventing docking at Portsmouth or Rosyth. The docking restriction, which had so hampered the designers of the *King George V* class, was finally rescinded. To help offset the weight increase due to the greater beam, side armor was reduced to 13.73

inches outside the main-battery magazines and 12.75 inches outside the machinery spaces.

On 17 April 1941 the design characteristics tabulated in Table 7-3 were approved.

The design was constantly reviewed to incorporate combat experiences of other ships, particularly the *Prince of Wales*. The cupolas of the 5.25-inch mounts were increased in size to permit the gun crews to be at battle stations for longer periods; this, combined with heavier splinter protection, forced the hydraulic pumps to be moved from the revolving to the fixed part of the structure.

The possibility of funnel gases being drawn into the air supply of the forward boiler rooms due to splinter damage to the air intake ducts was eliminated by installing the ducts in the forward superstructure, and leading the trunk aft to the boiler room.

The use of electric instead of oil-fired ranges in the galley permitted it to be divided into two spaces, either of which could serve the entire crew if the other was damaged.

The bridge was rearranged to benefit from combat operations and intensive wind-tunnel tests of the *King George V* superstructure. The original arrangement of high-angle directors, similar to that of the *King George V* class, was altered for greater flexibility of control.

There was a marked increase in the complement before the ship was completed, due to changes in antiaircraft armament, communications, and radar, as well as the change to fleet flagship status. This required more space for accommodations and more weight for personal gear, stores, fresh water, and provisions.

The ship was also fitted for tropical and arctic duty, with sprayed limpet asbestos applied to exposed sides, decks, and bulkheads. Steam heat was provided for many fittings, armament, exposed controls, and various working and berthing spaces and sea cocks. Some of these services had to be supplied with superheated steam, as there was not sufficient saturated steam available.

TABLE 7-3

Design Characteristics, 17 April 1941

Standard displacement	41,600 tons (42,268 mt)
Full-load displacement	48,000 tons (48,768 mt)
Waterline length	800 feet (244 m)
Waterline beam	108 feet (32.8 m)
Depth	42.5 feet (12.95 m)
Draft	
standard	29.50 feet (8.99 m)
full load	33.00 feet (10.06 m)
Armament	Eight 15-inch/42 caliber (Mark I/N) guns in four twin turrets. Sixteen 5.25-inch/50-caliber (Mark I) guns in eight twin mounts. Forty-eight 2-pdr pom-poms in six octuple mounts Four UP projectors Two aircraft
Maximum speed	29.5 knots at the standard displacement
Shaft horsepower	120,000 (121,664 mhp)—normal
Endurance	14,000 n. mi. at the 10-knot trial condition.
Fuel-oil capacity	4,100 tons (4,166 mt)
Protection	
main side belt	13.73" (348 mm)—magazines 12.75" (324 mm)—machinery
decks	5.88" (148 mm)—magazines 4.90" (124 mm)—machinery

The sheer was increased forward and the side plating designed to ease water flow around the bow structure when pitching into head seas. The anchor stowage was redesigned to minimize spray formation in head seas; by placing anchors in carefully designed recesses, each one could be stowed under the cable pull of the anchor windlass alone. An additional breakwater was added forward of "A" turret.

Longitudinal separation of the inboard and outboard propellers, based upon knowledge of the torpedo damage to the *Prince of Wales*, was increased from 33.5 feet to 51.5 feet.

All these alterations, with the exception of the relocation of the 5.25-inch handling room, had little effect on the committed work, and the Admiralty made every effort to see that the builder maintained the construction schedule.

Revised characteristics and building drawings, omitting the aircraft and featuring improved arrangements, were approved by the Board on 7 September 1942. The major features of the redesign are tabulated in Table 7-4.

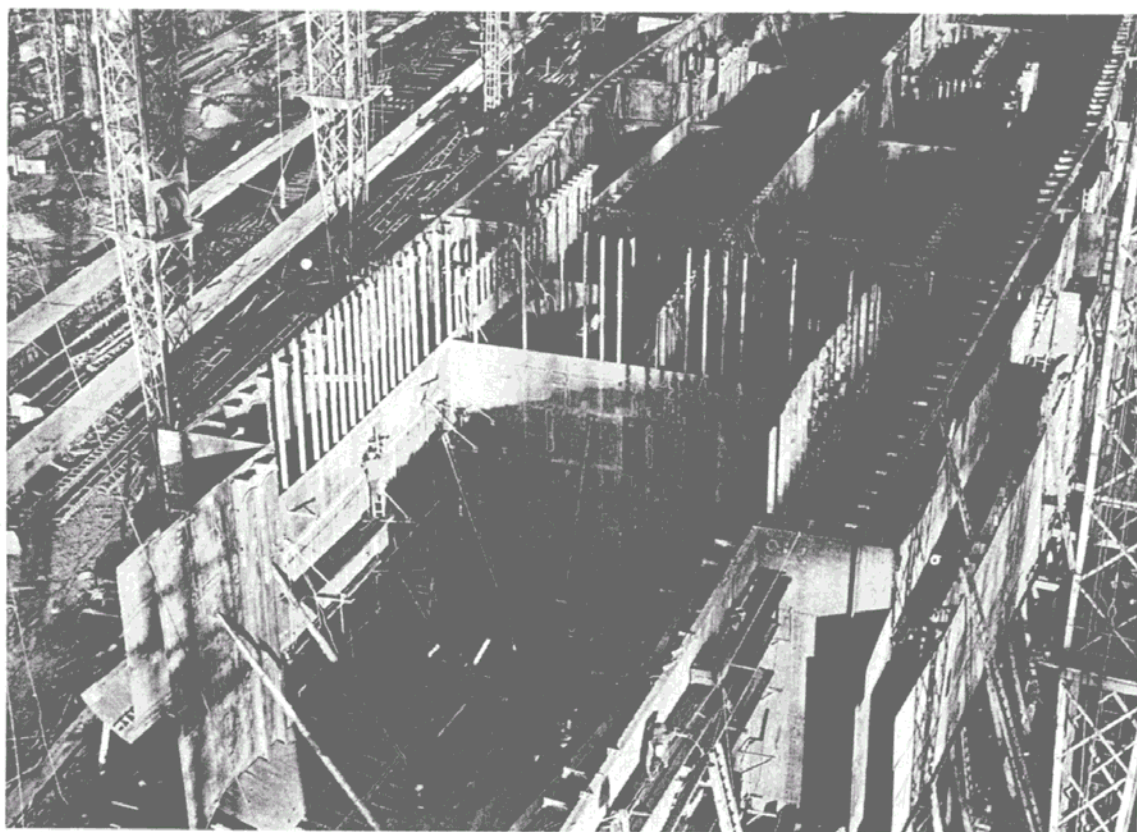
Final Characteristics, 7 September 1942

Standard displacement	42,300 tons (42,991 mt)
Full-load displacement	49,200 tons (50,004 mt)
Length on waterline	800 feet (244 m)
Waterline beam	108 feet (33 m)
Draft	
standard	29.83 feet (9.09 m)
full load	33.83 feet (10.31 m)
Armament	Eight 15-inch/42-caliber (381 mm)—paired Sixteen 5.25-inch/50-caliber (133 mm)—paired Seventy-six 2-pounders (pom-poms)—9 octupled 1 quad
Speed	Twenty-four Oerlikon machine guns—paired 29.5 knots (at standard displacement)
Shaft horsepower	120,000 (121,664 mhp)
Endurance	6,000 miles at 20 knots in a fouled condition
Fuel-oil capacity	4,850 tons (5,390 mt)
Protection—main side belt	13.73" (348 mm)—magazines 12.75" (324 mm)—machinery 5.88" (148 mm)—magazines 4.90" (124 mm)—machinery

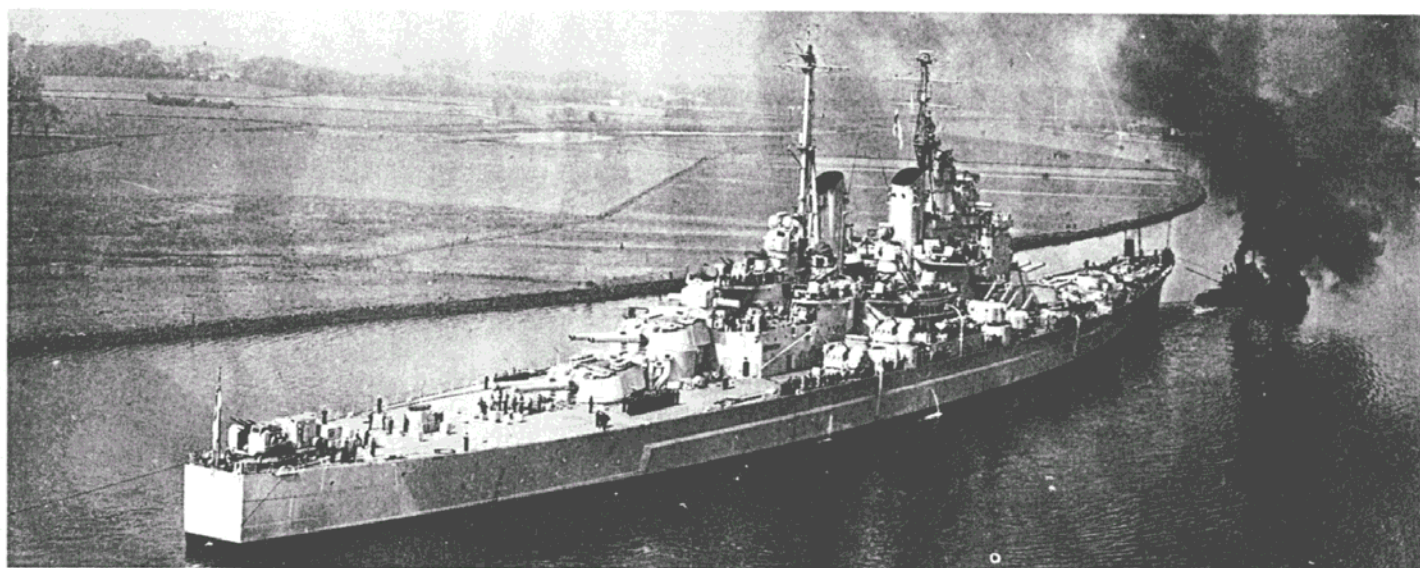
One of the most novel features of the *Vanguard* was a cafeteria-style mess with seven dining halls replacing the traditional group mess system, where the men ate and slept in the same space. This major change in the habitability standards was made because of space considerations and also as a measure to improve crew morale and efficiency. A chapel and motion picture theater were provided in space made available by the removal of the aircraft hangars and catapult.

The *Vanguard* had a unique profile and internal arrangement for a British battleship; in many respects, she closely resembled modern U.S. battleships. A sleek, utilitarian sheer line was combined with a compact superstructure and two well-proportioned funnels. The combat information center, air plotting, operations, and radar were all concentrated in one area. The ship had ten air-cooling units and two jet heating plants with a capacity of 500,000 BTUs per hour; crew living spaces and operational spaces, such as the CIC, computer rooms, and 5.25-inch magazines adjacent to the boiler rooms, were air-conditioned.

Vanguard—Operational History. The keel of the *Vanguard* was laid at John Brown and Company, Ltd., Clydebank, on 2 October 1941. The ship was christened by Princess Elizabeth and launched on 30 November 1944. The outfitting schedule was slowed while the desirability of completing an already obsolescent



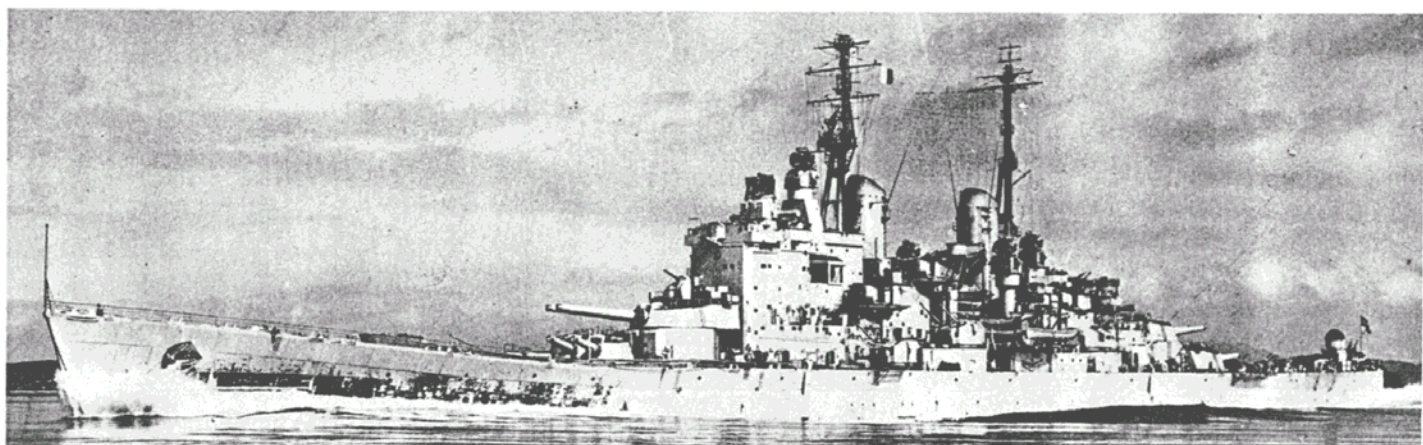
The keel of the *Vanguard* was laid at John Brown & Co., Clydebank, on 2 October 1941, and construction had proceeded this far by early 1943. Note the indentation of the torpedo bulkhead in the lower portion of the photograph. This was a characteristic feature of modern British battleships to minimize the disruptive impact of shafting passing through the side protection system. (Scottish National Archives)



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These are two views of HMS Vanguard leaving the John Brown Shipyard to join the British Fleet. Note the transom stern and the two proportioned funnels which gave her a distinctive appearance from other British battleships. (Scottish National Archives)

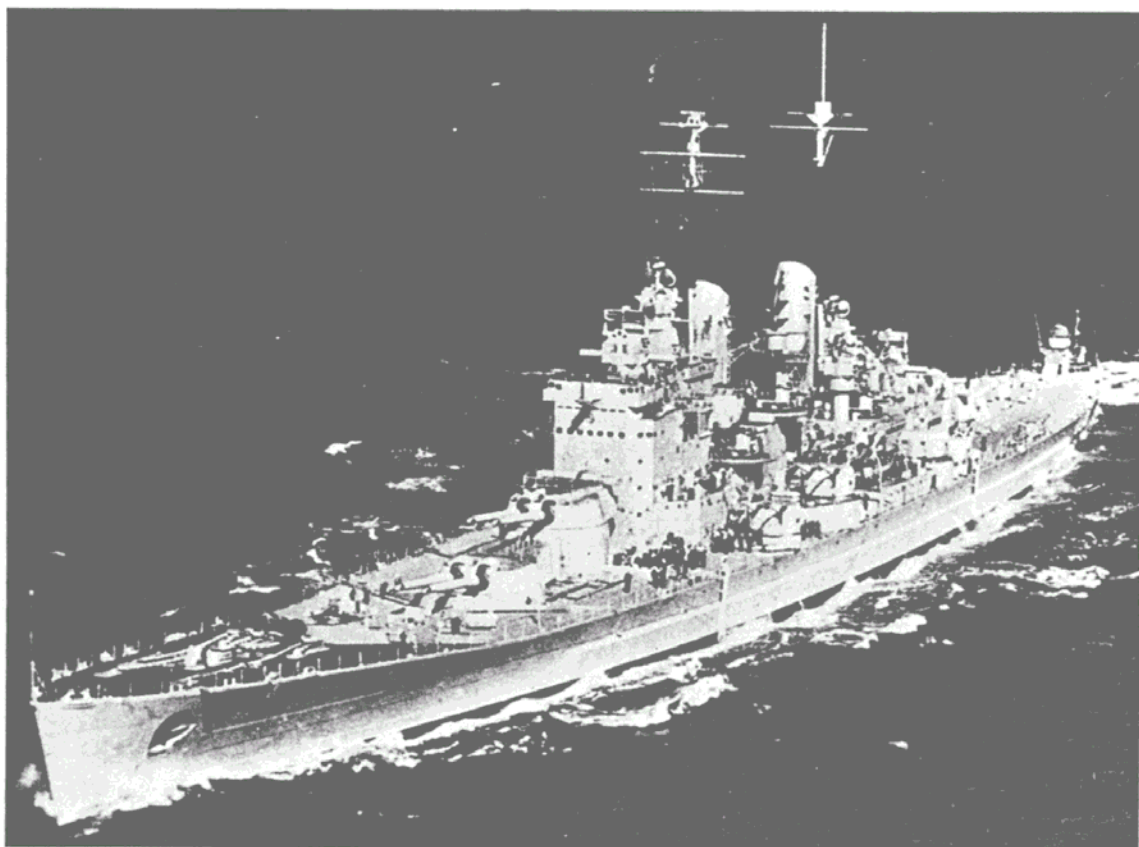


The Vanguard was the last British battleship to be designed and constructed. Mounting old 15-inch/42-caliber guns and turrets, which had been held in reserve for the Queen Elizabeth class, she was to be rushed to completion by 1944. This was not to be; she is shown here on trials in August 1946 off Arran. (Scottish National Archives)

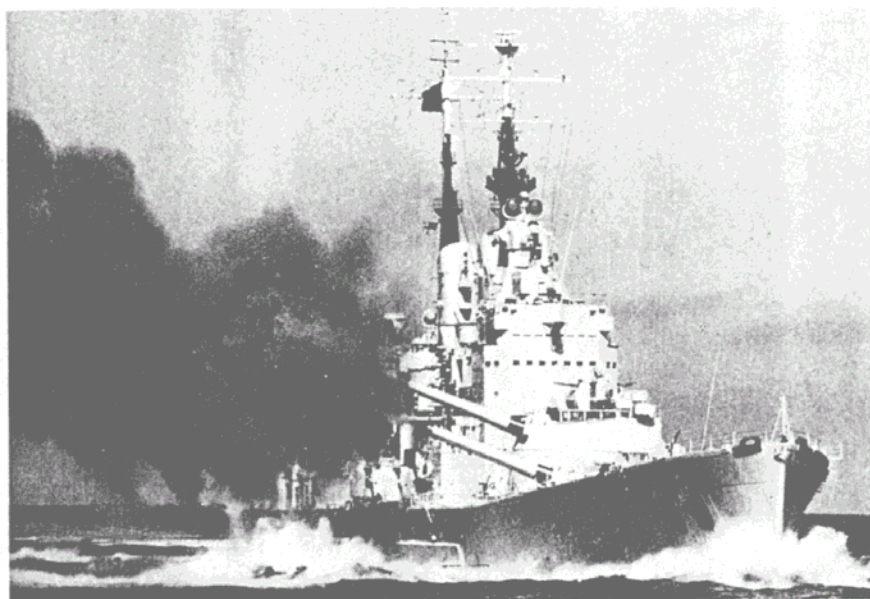
warship was debated. Earlier, in July 1942, a proposal to convert the hull of the *Vanguard* into an aircraft carrier had been rejected. Subsequent emphasis on aircraft carrier construction delayed her final completion, however; her first trials were run off Arran on 9 August 1946. She was the last battleship to be built for the Royal Navy.

Postwar operations. The *Vanguard* never fired her guns in anger. Shortly after she entered active service in 1947, she served as a royal yacht for a 12,000-mile, 3-month tour of South Africa by King George VI. During the ship's transit from the United Kingdom to South Africa, the French battleship *Richelieu* closed to within 1,600 yards of the *Vanguard* off Cherbourg and fired a 21-gun salute in honor of the Royal Family. Sailors on the French battleship lined the rails and cheered the Royal Family, and after exchanging salutes, the French battleship returned to port. An extensive overhaul then prepared her for a tour of Australia, which was canceled due to the King's illness. During the overhaul, washrooms were modernized with stainless steel equipment and hot and cold running water. Modern furniture, water coolers, and laundry equipment replaced older equipment. Barber and tailor shops were added. All overboard discharges, refuse chutes, accommodation ladders, and other outboard fittings were made demountable so the ship could transit the Panama Canal.

The ship was assigned to the British Mediterranean Fleet during 1949. After returning to Portsmouth on 21 July, she was fitted out for training duties and relieved the *Anson* in the Training Squadron, Home Fleet. From July 1949 until August 1952, the *Vanguard* conducted training cruises and rendered salutes to foreign dignitaries mak-



The Vanguard is shown at speed. Note that the spray formation problem at the bow, which so hampered the King George V class battleships, is not evident in the Vanguard. She was a dry and steady ship, even in rough weather. (U.S. Information Agency)



Salvo! The Vanguard fires a broadside at full speed during fleet exercises. The blast from the 15-inch/42-caliber guns kicks up spray abreast of the forward turrets.

The end of a line, the Vanguard arrives in Faslane in August 1960 for scrapping. (I. L. Buxton)

ing state visits to the United Kingdom. Admiral Sir Phillip Vian made her his flagship when he became commander in chief of the Home Fleet, September 1950. Subsequently, she was relieved by the *Indomitable*; however, on 12 May 1951 she was again made flagship of the Home Fleet. She was overhauled at Devonport, where weight increases finally forced the reduction of fuel oil to be carried in a full-load displacement to prevent overstressing the hull girder. Although the ship frequently served as flagship of the Home Fleet, she also served as flagship of the training squadron. On 15 June 1953 the *Vanguard* flew the flag of the commander in chief, Home Fleet, at the Coronation Naval Review. She was replaced as the flagship of the Home Fleet during September 1954. Shortly afterwards, at Devonport, a defect discovered in her stern casting lengthened her planned stay in the dockyard. All the multiple 40-mm mounts were removed to simplify maintenance when she was placed in reserve. While in reserve, the single 40-mm guns were also removed.

Final Disposition. Upon completion of her overhaul in March 1956, the ship was placed in the Reserve Fleet, and in June 1958 she was downgraded to extended reserve. On 8 June 1960 the *Vanguard* was relieved as flagship of the Reserve Fleet and on 4 August 1960 she was towed to Faslane on the Clyde to be scrapped.

Armament. The armament planned for the *Vanguard* had the characteristics tabulated in Table 7-5.

Main battery. The use of the older 15-inch/42 Mark I/N gun eliminated the need for the design, production, and testing of new gun mountings. However, changes were necessary to modernize the turrets by increasing the maximum elevation from 20 to 30 degrees. The face plates of the turrets were heightened and the ports enlarged. To compensate for these larger openings, the armor of the face plate was thickened. The

TABLE 7-5

Gun Characteristics

Gun	15"/42 caliber (381 mm)	5.25"/50 caliber (133 mm)
Shell weight (lbs)	1,938 (879 kg)	85 (38.6 kg)
Muzzle velocity (fps)	2,575 (785 mps)	2,600 (792 mps)
Maximum range (yds)	32,100 (29,252 m)	23,400 (21,397 m)
Elevation (degrees)	30	70
Gun	1.57"/56 caliber (40 mm)	
Shell weight (lbs)	1.98 (0.898 kg)	
Muzzle velocity	2,890 (881 mps)	
Maximum range (yds)	11,000 (10,058 m)	
Elevation (degrees)	90	

gun mountings were also strengthened to withstand increased loadings resulting from gunfire at higher elevations. Increased elevation and an improved shell resulted in an extreme range of 32,100 yards. The 15-inch AP shell, propelled by a 490-pound cordite charge, was actually superior to the *Nelson's* 16-inch shell in terms of penetration at long range. The 14-inch gun of the *King George V* class had inferior penetration at all ranges.

The 15-inch gun had armor penetration capabilities tabulated in Table 7-6.

The turrets were originally built for the *Glorious* and *Courageous*, in which the powder magazines were above the shell rooms. It was decided to reverse the arrangement in the *Vanguard*, as had been done in the *Nelson* and later battleships, to better protect the magazines against long-range shellfire. To simplify converting the mountings, powder-handling rooms were placed above the shell-handling rooms. Fixed hoists between magazines and handling rooms were protected by armor and fittings with flashtight doors top and bottom. Additional flash protection was obtained by stowing cordite charges in cases and moving them in box-cloth wrappers.

The 15-inch gun weighed 100 tons. Each twin turret with associated shell-room machinery weighed 904 tons, a sizable increase over the original installation. Turrets could train at two degrees per second; guns could elevate at five degrees per second. Each gun could fire independently, at a rate of two rounds per minute. The original sighting hoods on the roof were removed because optical rangefinders were part of the basic design, and there were no restrictions on axial firing of the superfiring main-battery turrets. The main-battery turrets were remotely controlled in training, and this, in combination with the secondary armament, made the *Vanguard* the only British battleship so fitted.

Hydraulic power for the main armament was produced by four turbopumps, each delivering 95 cubic feet per minute at a pressure of 1,000 psi. These pumps were in four separate auxiliary machinery rooms.

Secondary battery. The secondary battery consisted of sixteen 5.25-inch/50-caliber dual-purpose guns (Mark I) in twin mounts. Protection was increased relative to that

TABLE 7-6

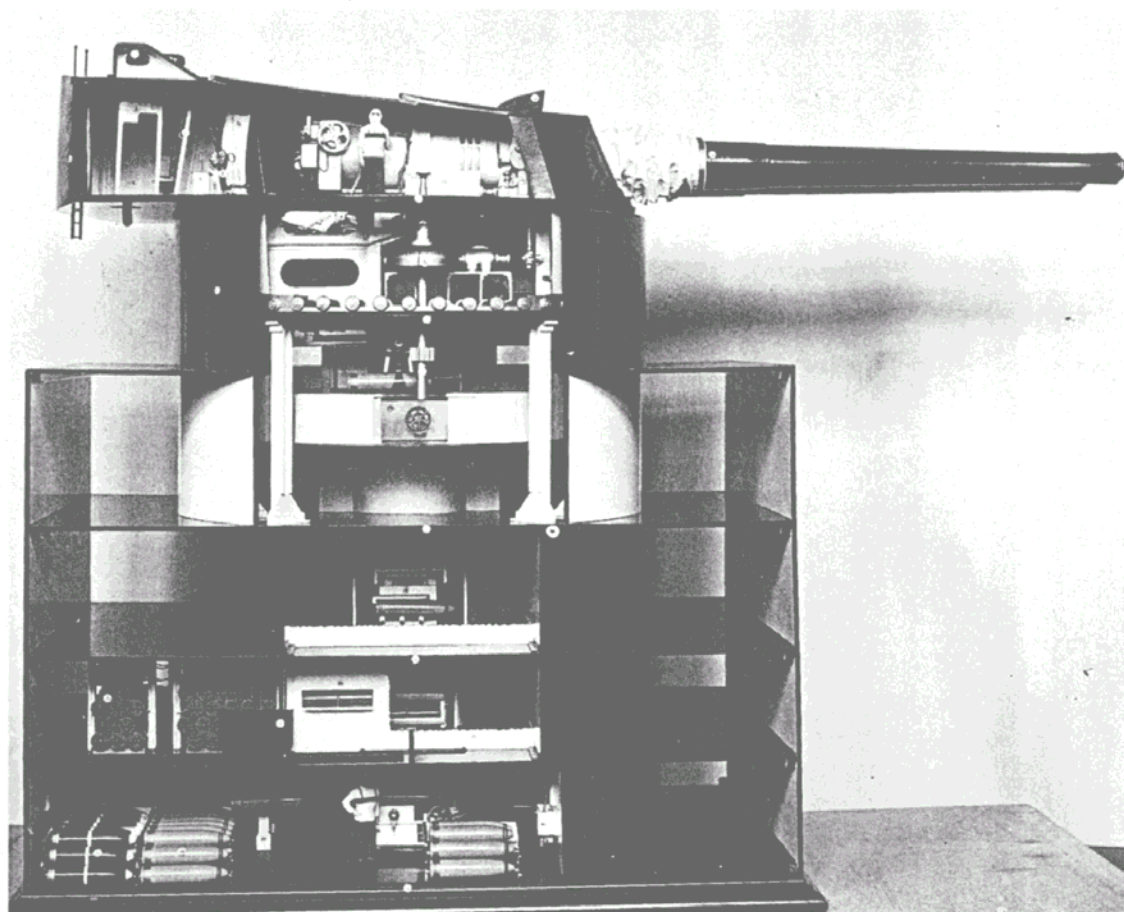
Armor Penetration Capabilities, 15-inch Gun

Range	Vertical plates	Deck plates
10,000 yds (9,144 m)	16.5" (421.6 mm)	1.25" (31.7 mm)
15,000 yds (13,716 m)	13.9" (353.1 mm)	1.95" (49.5 mm)
20,000 yds (18,288 m)	11.7" (297.2 mm)	3.10" (78.7 mm)
25,000 yds (22,860 m)	10.2" (259.0 mm)	4.30" (109.2 mm)
30,000 yds (27,432 m)	9.0" (228.6 mm)	5.70" (144.8 mm)

on the *King George V* class—each mount was 26 tons heavier than in the earlier ships. The guns were fully automatic and remotely controlled, with a rate of fire of eighteen rounds per minute. The antiaircraft ceiling was 49,000 feet, markedly superior to that of similar American or Japanese guns. The 5.25-inch guns were equipped with a fire-control system similar to that used in U.S. battleships of that period. Four MK-37 directors were arranged in a diamond pattern instead of the normal British "four-corner" disposition.

Antiaircraft battery. As the design progressed, it became evident that the originally conceived armament of pom-poms and UP mountings was inadequate. In September 1942 it was decided to increase the number of pom-pom barrels to seventy-six and to replace the UP launchers with twenty-four Oerlikon guns in twin mounts. War experience later showed that the relatively low muzzle velocity of the pom-poms diminished their effectiveness. British observers witnessing U.S. trials of multiple 40-mm Bofors mounts were convinced that American equipment was superior. Even with the addition of a rather cumbersome tachometric director, radar control, and power operation of the pom-pom mounts, they were inferior to the Bofors multiple mounts. Accordingly, the British developed the Bofors Mark VI, a multiple mount with six barrels, to replace the pom-poms. The *Vanguard* mounted ten Mark VI,

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A cutaway model of the 15-inch World War I turret of the type used on the *Vanguard* shows the shell and powder magazines and the gun chamber. The 15-inch gun was a mainstay in the Royal Navy and was used on the *Hood*, the *Revenge* class, the *Queen Elizabeth* class, the *Repulse* and *Renown*, and *Vanguard*, as well as several monitors and two unorthodox cruisers, the *Glorious* and *Courageous*. (Imperial War Museum)

eleven Mark VII single Bofors, and one twin-stabilized tachometric antiaircraft gun (STAAG—MkII). The power-operated Mark VII was especially fitted for defense against suicide attacks. The sextuple mounts were concentrated in the superstructure; the others were distributed forward and aft. The change to Bofors barrels made it necessary to rearrange the magazines and provide additional space. There was not enough space to stow the standard 1,564 rounds per barrel; the total ammunition stowage averaged 1,269 rounds per barrel, including ready service ammunition.

Subsequent to 1948, the Bofors battery was altered during overhaul as a weight compensation. Two quarterdeck singles were removed in 1949, and the last quarterdeck single and four others in superstructure were removed in 1954. During the *Vanguard's* last overhaul, when she was destined for the Reserve Fleet, all multiple mounts were removed to avoid maintenance problems, and only four singles, abreast of "B" and "X" turrets, remained. The ship had no 40-mm guns when she was scrapped in 1960.

The 20-mm Oerlikon machine guns were deleted from the design when their war-time performance proved inadequate. The Board of the Admiralty preferred to discard them in favor of added 40-mm (Mk III) machine guns, and this decision was adhered to in the completed ship.

Aircraft. The early versions of the *Vanguard* had aircraft facilities. In fact, the early designs made provision to carry aircraft at the fantail using a below-deck hangar and rotatable catapults or a fixed athwartships type. Such arrangements were being used on American battleships and the French *Gascogne* variant of the *Richelieu* class, and it did permit some additional antiaircraft guns in the midships portion of the superstructure where the aircraft arrangements had been planned to be located. Sir Stanley Goodall did not like this arrangement because:

- The hangar cover would have to be watertight;
- The location of the hangar at the stern was bad from a pitching response in following seas;
- The location of the large hangar below deck would disrupt major hull structure, leading to problems of vibration and hull strength continuity.

By 1941, the development of carrier aviation and radar had decreased the need for shipboard aircraft, and they were removed—making more space available for boat stowage and associated equipment, which was concentrated between the stacks. Space abaft the mainmast was freed for additional pom-poms, and Bofors.

Protection. Armor protection for the *Vanguard* was the most extensive ever given a battleship of the Royal Navy. The protective aspects were emphasized by directives on the ship's characteristics, which stipulated that she was to be heavily armored and absolutely impervious to torpedo and bomb attack. Although the main side belt thicknesses were slightly less than in the *King George V* and *Lion* classes, horizontal protection was not diminished. This protection was augmented by local armor in way of the magazines. In the early designs, the armor belts were 14.71 inches and 13.73 inches thick over the magazines and machinery respectively, but had to be reduced for weight compensation.

The main side belt, 460-feet long, covered 57 percent of the waterline length. It was not inclined. Over the machinery spaces it was 12.75-inch cemented armor plate; over the magazines it was 13.73-inch plate. The belt had a vertical extent of 24 feet,

and was fitted in three courses, two of constant thickness and a third tapering section. A splinter belt extended forward and aft of the citadel, protecting against damage by near-miss bomb or shell fragments and a consequent loss of stability. The armor belt forward of the citadel tapered from 13.75 inches and 24 feet wide to 1.96 inches and 8 feet wide at a point 12 feet from the stem. Aft, it tapered to the same thickness, 11 feet wide, beyond the steering-gear room. The after splinter belt was inclined for better resistance to shells. Remarkably extensive belt-armor protection was provided.

The belt abreast the magazines was proof against 15-inch shells outside 15,400 yards; abreast of the propulsion plant it was sufficient down to 17,600 yards. At the ends of the citadel, below the lower deck, the lower side belt was extended slightly forward and aft to protect magazines against 15-inch shells with oblique trajectories.

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Deck armor. Horizontal protection was designed to resist penetration by a 1,000-pound armor-piercing (AP) bomb dropped from 14,000 feet, and was also considered proof against 15-inch shells inside 31,000 yards. The armor thicknesses were the same as in the two previous battleship classes—5.88-inch noncemented armor plate over the main-battery magazines and 4.90 inches over the propulsion plant. Local protection was provided for all magazines by 1.47-inch noncemented armor plates over and around these spaces, for a total of 7.35 inches of armor protection. In addition, the armor decks were carried forward and aft of the citadel, two decks lower than the main armor deck, to provide a measure of protection against bombs for the extremities of the ship. The armor deck tapered from a thickness of 4.90 inches at the forward armored bulkhead to 2.45 inches at its termination 12 feet from the stem. The only cut in this deck was for the anchor windlass compartments. A 4.41-inch armor deck extended aft to protect the steering gear and propeller shafts. The deck armor at the extremities, particularly forward, was thicker than usual in modern battleship design.

Conning tower. In providing protection for the conning tower, communications tube, and fire-control directors, the Board of the Admiralty still held, as it did during the design of the *King George V* class, that the probability of a shell striking the tube or tower was extremely small, and heavy armor protection was unnecessary. The protection was slightly increased, but the conning tower and director protection remained extremely light in comparison with German, French, and American practice. The director armor was essentially the same as on most contemporary battleships. The secondary conning tower had 1.96-inch armor on its sides, and 1.47-inch armor on its roof.

The *Vanguard* was completed with light conning tower protection despite the heavy bridge damage sustained by the *Prince of Wales* in her action with the *Bismarck* and the conviction of the U.S. Navy that the *South Dakota* vindicated the decision to retain the heavily armored conning tower in its new battleships. The Royal Navy persisted in providing only protection sufficient to resist fragmentation damage or at best hits from 5-inch shells, even in vital ship-control areas. The absence of heavy conning tower armor was one of the most unusual characteristics of a British World War II battleship.

Armored bulkheads. The *Vanguard* had three armored bulkheads. The forward and after bulkheads were of 11.76-inch armor outboard and tapered to 9.81 inches at the centerline. Below the lower deck, where armor was fitted forward and aft of the citadel, the thickness was 1.47 inches. A third bulkhead, abaft the steering-gear room, was of 3.93-inch noncemented armor. Forward and aft of the main transverse armored bulkheads, one-inch protective plating was provided for all main transverse bulkheads to contain splinter damage and maintain watertight integrity.

Turret armor. The main-battery turrets of the *Vanguard* were more heavily armored than those on the *Glorious* and *Courageous*. Nevertheless, the armor bulkhead was at best still marginal for a World War II battleship. Alterations in the turret face plates necessitated heavier rear and deck armor plate to maintain turret balance. The bar-bette protection was the same as that used in the *King George V* class. (See figure 7-1.)

The 5.25-inch twin mounts had 2.21-inch armor on their sides and roofs, sufficient to withstand shell fragments and splinters, and 1.96 to 5.88-inch armor to protect the hoists. Despite the desirability of truly heavy protection, it was considered that such protection on these mounts would demand an inordinate price, in terms of other important ship characteristics and functions, especially with regard to stability.

The most significant development in the design of armor protection for the *Vanguard* was the extensive use of 0.98-inch and 1.96-inch Class B armor plate in exposed locations in the superstructure sides and decks to provide more splinter protection, based upon combat experience. With knowledge of shell damage to the USS *South Dakota* and *Prince of Wales*, and the inclusion of more electronic equipment, the Board of the Admiralty favored more armored protection for vital areas in the superstructure. The chart room and bridge areas had splinter protection; such protection in the *Prince of Wales* proved deficient in her engagement with the *Bismarck*.

During the action with the *Bismarck* on 24 May 1941, a German 15-inch shell hit the *Prince of Wales* below her main side belt and came to rest without exploding against the torpedo bulkhead. To prevent splinters from an exploding shell with a similar underwater trajectory from reaching the magazines in *Vanguard*, approval was given on 15 August 1941 to complete the protection of the longitudinal bulkheads of the main and secondary magazines with 1.47-inch noncemented armor.

Side protection. The side protection system introduced in the *King George V*-class battleships (and used in the *Illustrious*-class carriers) was retained, although the transverse depth of the system was increased. Table 7-7 summarizes the major characteristics of the system used in the *Vanguard*.

Liquids in the side protective system were located as far outboard as the underwater explosion theory would permit. This arrangement was intended to minimize the list resulting from damage to one side. The torpedoing of the *Prince of Wales* had also indicated that certain weaknesses existed in the side protection system of the *King George V*-class battleships. The great volume of void space outside the torpedo bulkhead caused very large lists, and there was a weak point at the ends of the armored citadel, where the beam began to decrease. However, the greater beam in the *Van-*

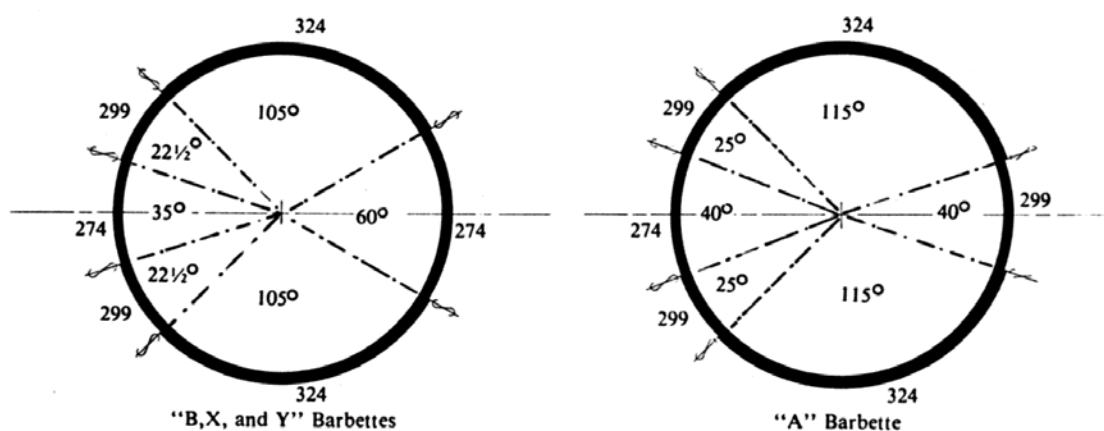


Figure 7-1. Barrette Armor Thicknesses for Vanguard

TABLE 7-7
Characteristics of Side Protection System

Location	Depth of System at Half Draft	Torpedo Bulkhead Thickness	Total Bulkhead Thickness
"A" Turret	10.25' (3.12 m)	1.47" (37 mm)	2.47" (63 mm)
"B" Turret	13.00' (3.96 m)	1.47" (37 mm)	2.47" (63 mm)
Amidships	15.00' (4.57 m)	1.47" (37 mm)	2.47" (63 mm)
"X" Turret	10.25' (3.12 m)	1.47" (37 mm)	2.47" (63 mm)
"Y" Turret	13.75' (4.19 m)	1.47" (37 mm)	2.47" (63 mm)

guard and the larger fuel-tank volumes in the wing tanks of her side protection system removed some of these weaknesses. The side protection system was still rather shallow, particularly outside of "A" and "X" turrets, where the system could withstand explosive charges of approximately 850-900 pounds of TNT. Where basic changes were not involved, other faults in the system revealed in the torpedoing of the *Prince of Wales* were corrected. The most important changes were the redesign of the pumping system for ballasting and deballasting void compartments in the protective layer and the removal of washrooms over the side protection system. It was accepted that the original washroom areas had to be considered spaces where the pressure wave could be vented. This conclusion was derived from the investigation into the loss of the *Prince of Wales*. The longitudinal bulkheads forming the side protection system were extended one deck higher. This formed a firm foundation for the torpedo bulkheads within the system, so that large deflections would not result in the destruction of watertight integrity in the deck between the side protection system and the interior spaces of the ship.

Relocation of the washrooms was simplified, since the removal of the catapult and hangar arrangement made space available for those living spaces.

The side protection system closely followed the principles outlined in the introduction to this book, with the exception of the venting. Increased wing fuel-oil capacity permitted the greater absorption of energy by the liquid layer than was possible in the *King George V* class.

The underwater protection, based on the results of full-scale experiments, was considered proof against a 1,000-pound TNT charge in contact with the ship's side at half draft over much of the length of the citadel. In way of "Y" turret, where the hull rapidly narrowed and the shafting began to emerge from the hull, the torpedo bulkhead was brought abruptly inboard to provide additional space for the torpedo defense system and adequate structural continuity for the shaft alley bulkheads. Salt water or fuel oil in the central space was to be kept within two feet of the tank top (middle deck). Auxiliary machinery rooms, immediately inboard of the bulkhead, would have flooded if the bulkhead were defeated. The units were dispersed in the event of flooding in an auxiliary space, and an ample power surplus was provided each in case some were damaged or the space flooded.

Subdivision and stability. The subdivision was very similar to that of the *King George V*-class ships, with watertight bulkheads dividing the *Vanguard* into twenty-one watertight compartments. Access to such compartments was provided by vertical trunks below the middle deck, and trunk sills were raised to reduce the chance of progressive flooding, which had contributed greatly to the loss of the *Prince of Wales*. It was found that this ship should be designed so that if spaces were evacuated hurriedly and doors left open or partially secured, flooding would not spread. This involved providing watertight trunks from vital spaces to the deck where watertight

TABLE 7-8

Stability Characteristics, HMS Vanguard

Condition	Displacement	Draft	GM
Full load	51,420 tons (52,260 mt)	35.06' (10.69 m)	8.20' (2.50 m)
Standard	44,500 tons (45,227 mt)	31.00' (9.45 m)	5.79' (1.76 m)

bulkheads terminate. The *Vanguard* was the first British battleship to be so equipped, and it was a difficult problem to find space for the trunks. One of the largest single weight additions during the 1942 redesign involved installing trunks.

Further precautions to arrest progressive flooding and reduce the adverse free surface effects of the flooding water relied on the use of longitudinal and transverse dwarf bulkheads which, added to the decks near the waterline and only at the sides of the ship, tapered down gradually to intersections with longitudinal bulkheads of similar heights. They also formed sloping pens which would confine flooding to relatively small areas. Watertight doors were fitted wherever access was necessary. Similarly, with the exception of a small V-shaped area on the centerline clear of any reasonable damaged-condition waterline, all penetrations of the main transverse bulkheads were made watertight. Careful design detail was mandatory for the best possible resistance to damage and flooding.

The static range of stability and the metacentric height of battleships were important indices of their ability to sustain damage without the undue loss of stability. The changes made in the *Vanguard* during her design and construction periods reduced her range of stability and her metacentric height (GM). This was inevitable since many of the alterations involved topside equipment (armament included). The stability characteristics of the *Vanguard* as she was completed in 1946 are summarized in Table 7-8. The metacentric height in the full-load condition compared favorably with that of contemporary battleships. At the "Admiralty light" displacement, the range of stability was reduced to 60.7 degrees; at the "average action" displacement it was 65.3 degrees.

Radar. The close cooperation between the United States Navy's Bureau of Ships and the Admiralty's Ship Design Division during World War II greatly facilitated the design of radar equipment and supporting structures. Many combat lessons were incorporated in the design of the electronics installation that far exceeded that of earlier battleships of the Royal Navy at the time of their commissioning. Unlike the masts of the *King George V* battleships, the foremast and mainmast were designed when the hull construction was well advanced and the amount of radar equipment was definitely established. The types of radar installed on the *Vanguard* have been tabulated in Table 7-9.

The *Vanguard* was fitted with an Action Information Centre (U.S. Navy—Combat Information Center—CIC). Its general layout included an air-plotting room, operations room, and a radar display room. When the A.I.O. Committee decided to include such a space in the *Vanguard* in September 1943, the Director of Air Warfare and Flying Training stated that the internal layout of the air plot, target indication, and operations room would be drawn up nearer the completion date for the ship, as it was impossible to forecast the exact requirements so far ahead. A replica of the action information center was made, and the layout of the admittedly small spaces was agreed upon.

TABLE 7-9

Radar Equipment, HMS Vanguard

<i>Function</i>	<i>Number</i>	<i>Type</i>	<i>Location of Aerial</i>
Air and surface search	1	960	Mainmast
Air search	1	281B*	Mainmast
Pointer	1	293P	Foremast
Surface search	1	277P	Foretop
15-inch gunfire control	2	274	Two main directors
5.25-inch gunfire control	4	275†	Mark 37 directors
40-mm gunfire control	11	262	Each sextuple and the STAAG mounts
Navigation	1	260	Mainmast

* Later replaced by air search radar, type 960.

† Mark 37 directors were supplied by USN but mounted British radar.

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Propulsion Plant. Great emphasis was placed upon speed, with the proviso that it was not to become so excessive as to adversely affect either the protection or armament. Since displacement and dimensions had been increased relative to earlier ships, increased power was necessary to maintain equality with the *King George V* class.

The designed overload shaft horsepower of 130,000 was sufficient for a maximum speed of 30.25 knots at the originally designed standard displacement and 29 knots at full-load displacement. The design requirements for the maximum speed were exceeded, primarily because the propulsive efficiency was better than expected and there was an efficient propeller separation. A speed of 31.57 knots was attained at 256.7 rpm with 135,650 shaft horsepower at a 45,720-ton standard displacement. A trial speed of 30.38 knots was made at 250.4 rpm with 132,951 shaft horsepower and a 51,070-ton deep displacement.

The ship was driven by eight Admiralty-type boilers and four sets of Parsons single-reduction geared turbines, designed to deliver maximum shaft horsepower at 250 rpm. The machinery was divided into four plants, with the turbines and boilers in separate spaces. Each plant worked independently under battle conditions but could be cross connected for emergency use in the event of damage or flooding.

Boilers. Each boiler room was equipped with two boilers that operated at a rated pressure of 400 pounds per square inch and a temperature of 700 degrees Fahrenheit. The boilers were a three-drum small-tube type with a common closed stokehold under forced draft. The type of boiler and its arrangement were identical to those of the previous battleship class.

Turbines. Each engine room contained two main turbine sets, each driving a shaft through double helical gears at a working pressure of 350 pounds per square inch and a temperature of 700 degrees Fahrenheit. The normal maximum was 30,000 shaft horsepower at 245 rpm for each turbine set, but 32,500 shaft horsepower at 250 rpm was specified for the overload condition. An astern turbine was incorporated in the casing of each low-pressure turbine; cruising turbines were omitted to save weight.

A single 10:1 reduction gear reduced turbine speed to an efficient shaft speed. The 250 rpm and the small propeller diameter of 14.75 feet produced higher than expected propeller efficiency. Increased efficiency could have been obtained using higher turbine speeds, larger propeller diameters, and double reduction gears.

The general arrangement of the propulsion plant was similar to that of the *King George V* class. Detailed improvements were made at various times during the *Vanguard's* construction and included:

- Additional lagging in engine and boiler rooms to improve working conditions.
- Improved brickwork in boiler furnaces.
- Exhaust doors from boiler rooms to uptakes for in-port ventilation.
- Additional drain coolers.
- Hotel steam separated from main steam system.

The propulsion plant included shock mounts, improved furnace fronts and oil burners, and redesigned shaft glands and bearing supports. Main steam valves were hydraulically operated and remotely controlled. An independent main steam supply to each of the four machinery groups precluded a general loss of steam in the event of damage to any one. The need for such improvement was indicated by flooding after damage in the *Belfast* and *Prince of Wales*.

In all early designs, including the one dated March 1941, specified endurance was 14,000 nautical miles at 10 knots under trial conditions. During 1941, consideration was given to the endurance of foreign battleships and the performance of the *Prince of Wales* and *King George V* during the chase of the *Bismarck*. It was found that Britain's latest battleships had an operational range of less than 5,500 miles, and the decision was made to increase it to 6,000 miles at 20 knots under battle conditions. Final endurances were 6,660 miles at 12 knots (102 rpm), 5,500 miles at 18 knots (148 rpm), 4,780 miles at 24 knots (202 rpm), and 3,380 miles at 28 knots (242 rpm).

The *Vanguard's* endurance was superior to that of the *King George V*-class ships even after their fuel capacity was increased, the result of lower fuel consumption rates in all conditions—0.64 pounds per horsepower hour at full power as compared to 0.80 for the earlier ships. The original endurance was based on 4,100 tons of fuel in double bottoms and wing tanks. Total fuel-oil capacity in the completed ship was 4,850 tons, including 427 tons of diesel oil. Fuel capacity was increased by widening the outboard wing fuel-oil tanks by 2.25 feet amidships and providing emergency stowage of 300 tons in tanks under "A" and "Y" barbettes. Since the side protection system displaced fuel oil by salt water, a more effective means of handling fuel-oil contamination was sought by the installation of a Coastguard Separating Plant.

Electric plant. In the original design, 220-volt DC electrical power was produced by six turbogenerators and two diesel generators supplying a ring main. After the *Belfast* had experienced a total loss of steam and severe disruption of electric power when a mine detonated below her keel, it was decided to install four diesel generators and four turbogenerators. The final arrangement featured two 450-kw diesel generators forward of the machinery spaces, and two abreast the after engine rooms. There were two 480-kw turbogenerators abreast of the forward boiler rooms and two in an auxiliary (harbour) machinery room between the forward engine rooms. The total output was 3,720 kw, the greatest for any British battleship.

Hull Characteristics. The *Vanguard* had no bulbous bow, due to the belief that it would reduce endurance at lower speeds by increasing drag. To compensate for this, a unique type of hull form was sought that would feature a very efficient longitudinal distribution of displacement in order to reduce the hull resistance. Other hull features affecting propulsion—such as the stern profile, draft, and beam—resulted from design considerations, including docking limitations. The stern was cut square,

as in the *Lion*-class ships, primarily to improve speed at full power. Experiments indicated that this might amount to a third of a knot. The *Vanguard* was the only commissioned British battleship with a transom-type stern. Increased length was the consequence of the desire for an improved length-beam ratio, essential for high speeds, while the demands of underwater protection against torpedoes, and additional wing-tank capacities, resulted in increased beam.

Vibration. The three-bladed manganese-bronze propellers created severe axial vibrations of the inboard shafts at speeds in excess of 180 rpm during trials. As a temporary measure, the outboard shafts were limited to that speed to prevent propeller interaction, with resultant axial vibration of the inboard shafts. After tests, it was decided to fit five-bladed propellers to the inboard shafts to obtain smooth operation at all speeds. Following trials with the new propellers, the ship was limited to 10 degrees of rudder when turning at speeds above 200 rpm; turns at 156 rpm were to be avoided. The problem was never corrected, merely avoided.

Freeboard. The *Vanguard* was initially designed with the same flat sheer lines as in the *King George V* and *Lion*-class ships. Combat operations against the *Bismarck* proved that the concept of firing "A" turret dead ahead at zero elevation, which demanded lack of sheer forward, must be abandoned, and that zero-elevation fire was very severe on adjacent structure, as was proven when a blast from the *Rodney's* 16-inch guns in that action caved in a good portion of her forward main deck. The *King George V*-class ships performed poorly in heavy weather and frequently had to slow to avoid taking water over the bow, a situation which could have been alleviated with more freeboard forward.

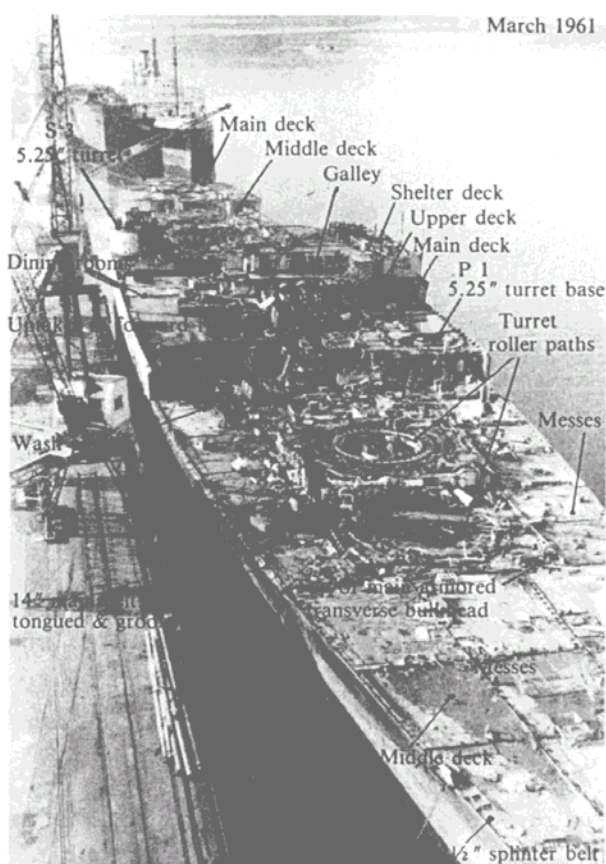
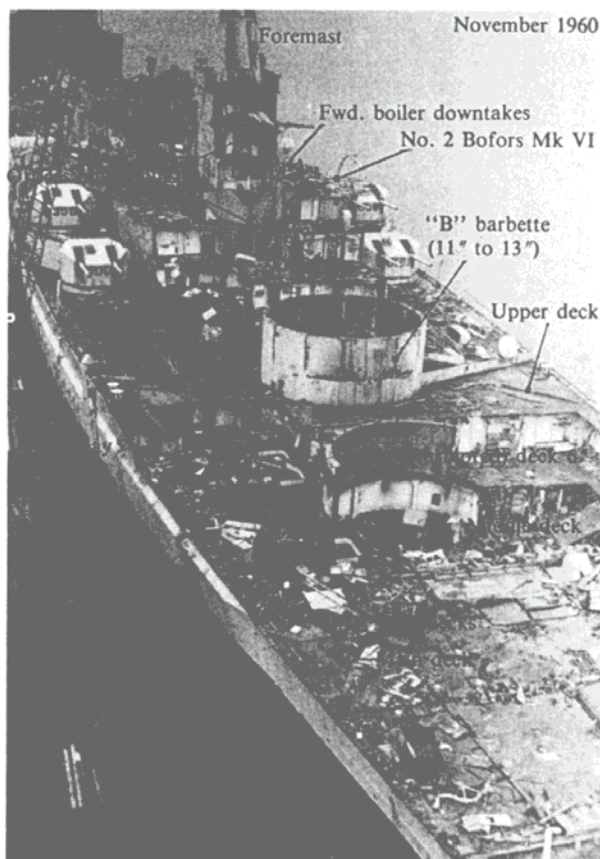
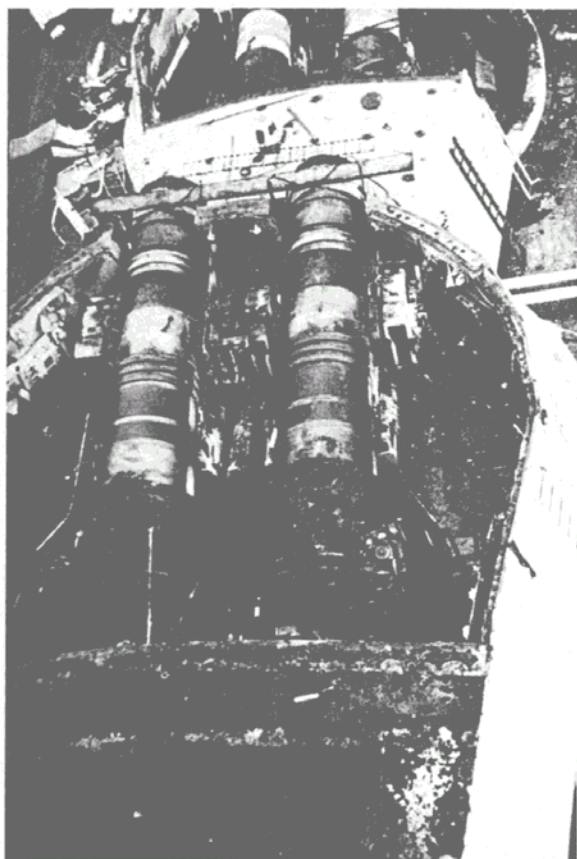
As speeds of from 25 to 30 knots were considered necessary in the *Vanguard*, three different schemes were proposed to increase the forward freeboard before it was finally decided to alter the sheer line by raising the level of the upper deck at the stem by 4.5 feet. It was accepted that "A" turret would have restricted arcs of fire. The new bow profile proved successful in service, and the *Vanguard* was dry and steady in heavy seas; three breakwaters, one on the forecastle, one forward of "A" turret, and one abreast of "B" turret, augmented her dryness in severe weather.

Welding. The main hull structure was riveted, although suitable manual and machine-welding techniques were available. The requirement for speed in construction, the lack of skilled welders, and the availability of skilled riveters, forced the acceptance of a riveted hull. There was no prospect of reducing construction time by welding, due to the priority demands of antisubmarine craft construction, which was dependent on prefabrication and welding techniques. Welding was limited to nonstrength members and T-bar stiffener connections to plating. The entire main hull girder, armament foundations, and the side protection systems were riveted.

Strength. Calculations of the *Vanguard's* longitudinal strength in 1945 indicated that stresses would exceed desired levels in the full-load condition. The director of naval construction limited the mean draft to a maximum of 35 feet in order to avoid excessive structural strain in heavy weather; the draft could be exceeded only for urgent operational needs. The commanding officer, all the Admiralty departments, and the drydocks were instructed that all proposals for alterations and additions must be accompanied by recommendations for removal of equivalent weights. Even so, split seams developed on trials due to structural overloads and defective steel. The displacement was maintained, but not reduced, in subsequent overhauls.

On delivery, the ship displaced 2,200 more tons than when the design was finally modified in 1941, due primarily to additional structure (470 tons), improved antiair-

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The three photographs above show the Vanguard during various stages of her scrapping. The upper photo shows the forward main-battery turrets with the 15-inch guns cut off. The middle photo shows the progress of the scrapping by November 1960. The remaining main armor deck, 5.25-inch guns, 13.73-inch main side belt, forward barbettes, and the remainder of the forward stack can be seen. The lower photograph shows what remained of the Vanguard by March 1961. The main side belt and a good portion of the superstructure has been removed. (I. L. Buxton)

craft battery (420 tons), increases in electrical power and lighting (500 tons), improvements in ventilation (200 tons), and changes in pumping, drainage, and ballast systems (170 tons). The ship also featured a combat information center (action information centre), the first and last British battleship to be so equipped. The first inclining experiment in June 1946 showed that the displacement in the full-load condition would be 51,402 tons at a mean draft of 35 feet.

Summary. The *Vanguard* was one of the best-protected ships built for the Royal Navy, although her World War I 15-inch guns were an unfortunate but necessary choice. Their maximum range was only 32,100 yards, less than that of more modern guns. A comparison of the guns of the four major European naval powers—Germany, Italy, France, and Great Britain—is shown in Table 7-10.

The armor protection and underwater protection systems were improved versions of those in the *King George V*-class battleships, although the lack of displacement restrictions made it permissible to construct a ship much larger than actually resulted. The United Kingdom could not afford the cost of a truly giant warship, and the *Vanguard*, largely as a result of using "off the shelf" guns and mountings, actually cost less than the earlier, smaller *King George V*-class ships. Although armor protection was extensive, with improved protection for many important areas in the superstructure, the conning tower remained extremely vulnerable to heavy shellfire or bombs.

Unfortunately, the propulsion plant was no more advanced than that in the *King George V*-class ships. Some improvements were made where operations of the five battleships in the previous class so dictated. These involved the fuel and saltwater separation and an increase in auxiliaries using electrical power. However, improvements in specific fuel consumption were slightly offset in 1952 by a reduction in the permissible fuel load.

In 1955 it was proposed to convert the *Vanguard* to a guided-missile ship. The proposal was abandoned because of problems with the cost of conversion and deployment, and the tactical use and development of a suitable missile. It was decided to scrap the ship rather than incur the expense of converting her and maintaining a hull that was over ten years old. Unquestionably, the circumstances that caused the *Vanguard* to be strength-limited lessened any chances of reconstruction and conversion, but anticipated cost considerations and construction difficulties were of primary importance in the final decision to abandon further studies of possible conversions.

The *Vanguard* was one of the best battleships built for the Royal Navy, although her inferior armament and strength limitations somewhat diminished her potential. Very good protection, especially with respect to the hull structure, was one of her characteristic features. While she could not match the stature of the *Queen-Elizabeth*-class battleships of the World War I era, she was definitely the best battleship built for the Royal Navy during World War II.

TABLE 7-10

Fifteen-inch Gun Characteristics of Four European Battleships

Ship	Gun Caliber	Shell Weight	Range	Maximum Elevation
<i>Bismarck</i>	15-inch (380 mm)/47	1,764 (800 kg)	39,590 (36,200 m)	30°
<i>Vittorio Veneto</i>	15-inch (381 mm)/50	1,951 (885 kg)	46,800 (42,800 m)	35°
<i>Richelieu</i>	15-inch (380 mm)/45	1,958 (888 kg)	43,715 (40,000 m)	35°
<i>Vanguard</i>	15-inch (381 mm)/42	1,938 (879 kg)	32,100 (29,252 m)	30°

Name *Vanguard*
 Builder John Brown & Co., Ltd., Clydebank
 Laid down 2 October 1941
 Launched 30 November 1944
 Commissioned 9 August 1946
 Operational 1 February 1947
 Disposition Purchased for scrap and broken up by Shipbuilding Industries, Faslane, commencing on 4 August 1960.

Displacement

(1946) 46,102 tons (46,842 mt) Standard
 (1946) 51,420 tons (52,245 mt) Full load

Dimensions

814' 4.13" (248.31 m) Length overall
 799' 11.13" (243.82 m) Length on waterline
 759' 11.63" (230.64 m) Length between perpendiculars
 108' 0.0" (32.92 m) Beam
 32' 0.0" (8.13 m) Mean draft at 46,102 tons.
 35' 0.88" (10.69 m) Mean draft at 51,420 tons.

Hull Characteristics at Standard Waterline

Displacement 46,102 tons (46,842 mt)
 Mean draft 32' 0" (8.128 m)
 Hull depth amidships 52' 6" (16.002 m)
 Freeboard at bow (no trim) 35' 6" (10.820 m)
 Freeboard at stern (no trim) 23' 6" (7.162 m)
 Block coefficient 0.583
 Midship section coefficient 0.99
 Prismatic coefficient 0.589
 Tons per square inch immersion 141.5 (56.600 mt/cm)
 Actual GM 8.2 feet (2.499m) at 51,420 tons (52,245 mt)

Armament

Eight 15-inch/42-caliber guns (Mark I/N) (381 mm)
 Sixteen 5.25-inch/50-caliber guns (Mark I) (133 mm)
 Antiaircraft

Year	Mk VIII Pom-pom 8-barrel	Mk IV Pom-pom 4-barrel	Mk VI— 40 mm Bofors 6-barrel	Mk II— STAAG 40 mm Bofors 2-barrel	Mk VI— 40 mm Bofors 1-barrel	20 mm Oerlikon Twin	UP
1940	6	none	none	none	none	none	4
1942	9	1	none	none	none	24	none
1946	none	none	10	2	11	none	none
1954	none	none	10	2	4	none	none
1956	none	none	none	none	4	none	none

Armor Protection

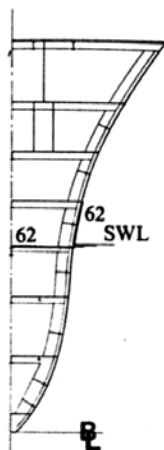
Immunity zone

From 15,400 yards (14,082 m) to 33,000 yards (30,175 m)—Magazines
 From 17,600 yards (16,094 m) to 27,100 yards (24,962 m)—Machinery
 against 15"/42-caliber (381-mm) gun firing a 1,938-pound (907-kg) shell.

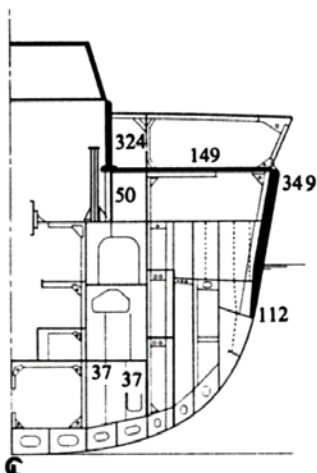
Amidships

belt armor 12.75" (324 mm) tapered to 3.83" (97 mm) at lower edge of lower strake.
 deck armor 4.90" (124 mm)

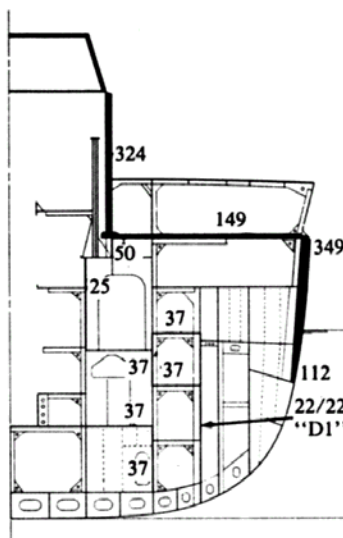
Frames



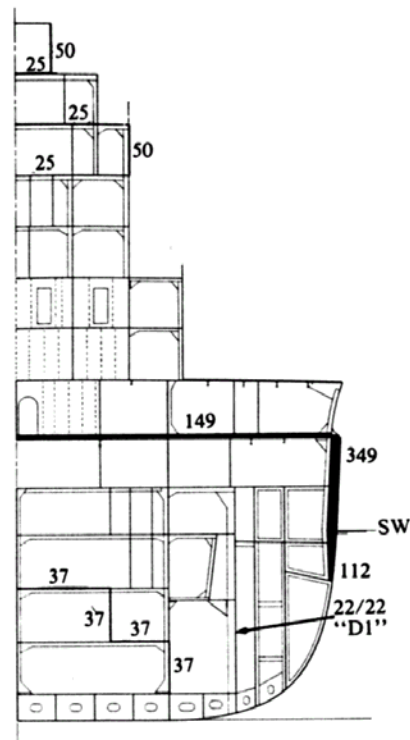
Section at FR.20



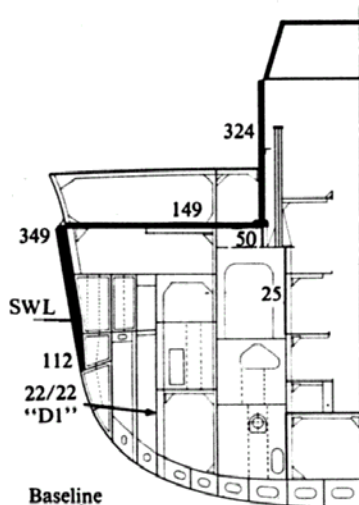
Section at FR.83 "A" Barbette



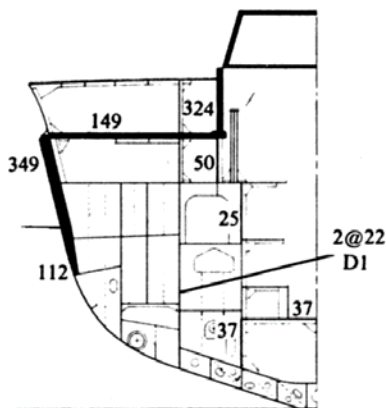
Section at FR.101 "B" Barbette



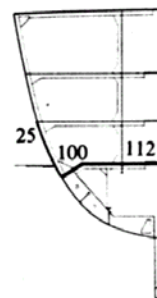
Section at FR.122



Section at FR.256 "X" Barbette



Section at FR.284 "Y" Barbette



Section at FR.329
steering gear room

Barbette armor

centerline forward	11.88" (300 mm)
sides	12.75" (324 mm)
centerline aft	10.82" (275 mm)

Turret armor

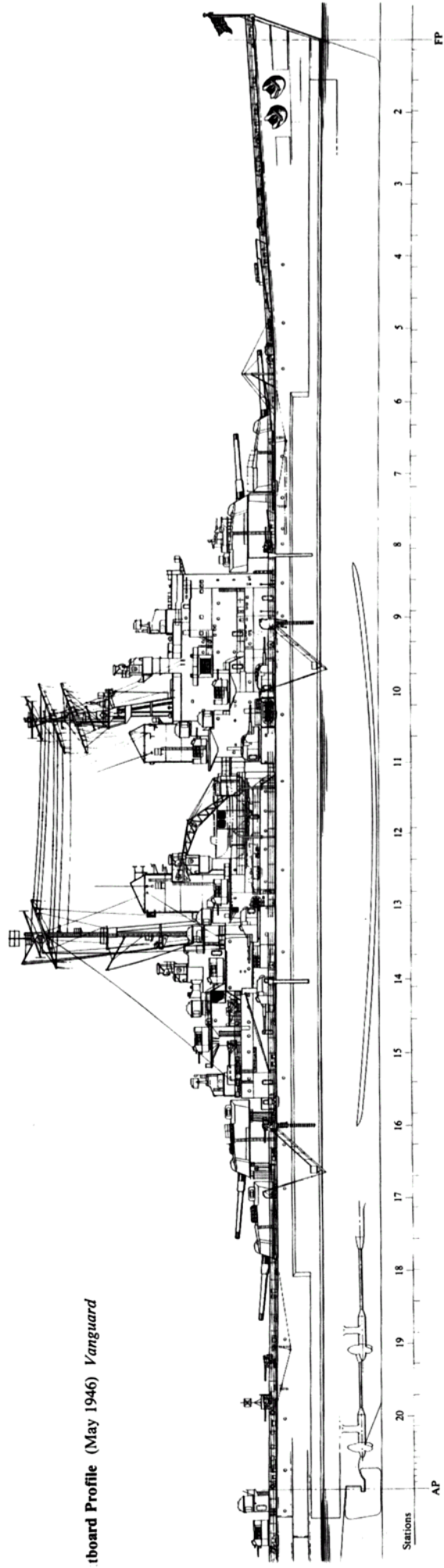
face plates	12.75" (324 mm)
sides	10.78" (274 mm)
back plates	6.86" (174 mm)
roof plates	5.88" (149 mm)

Secondary gun armor

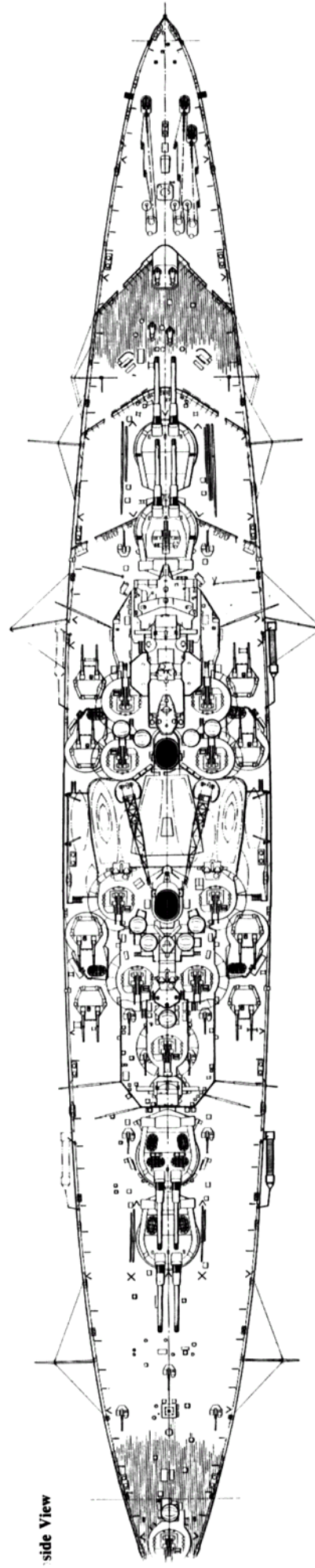
gun mounts	1.96" (50 mm)
ammunition hoists	2.21" (56 mm)
hoist ring at main deck	6.86" (174 mm)

Conning-tower armor

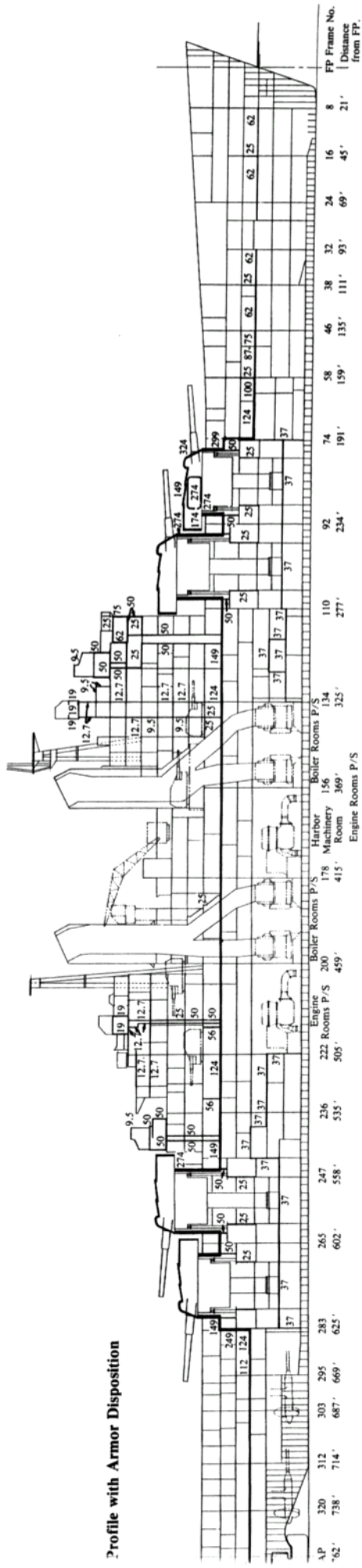
centerline forward	2.94" (75 mm)
centerline aft	2.45" (63 mm)
beam sides	2.45" (63 mm)
roof plates	0.98" (25 mm)
bottom plate	1.96" (50 mm)
communications tube	1.96" (50 mm)

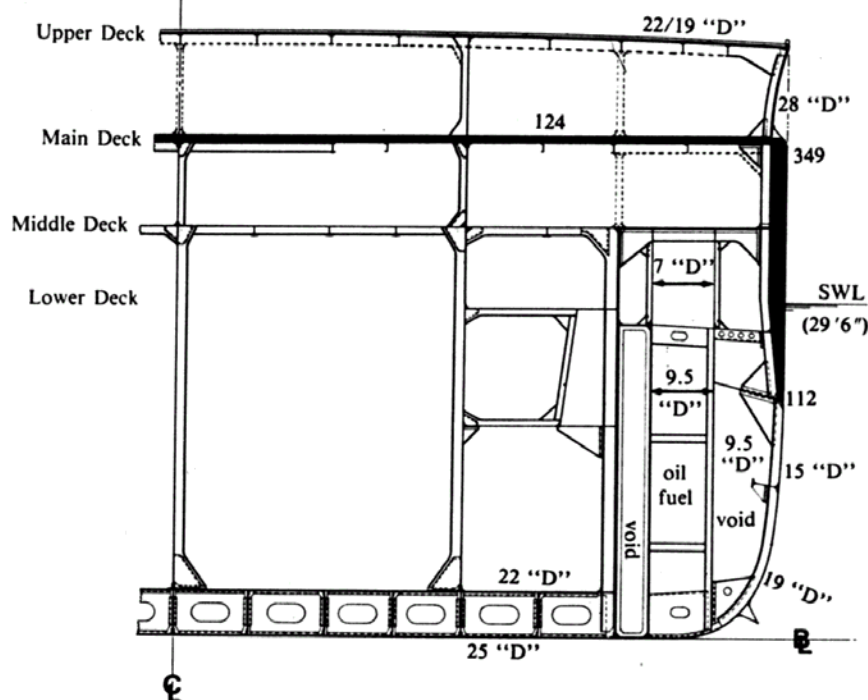
Onboard Profile (May 1946) Vanguard

side View



Profile with Armor Disposition



Midship Section**Underwater Protection**

Designed resistance 1,000 pounds (454 kg) of TNT.
 Side protective system depth 15.00 ft. (4.57 m) at half draft amidships.
 S.P.S. designed loading void-liquid-void
 Total bulkhead thickness 2.47" (63 mm)
 Bottom protective system depth 28' 0" (8.53 m) one layer

Tank Capacities

Fuel oil 4,513 tons (4,596 mt)—1946
 Diesel oil 427 tons (434 mt)
 Reserve feed water 358 tons (364 mt)
 Potable water 389 tons (395 mt)

Machinery

Boilers eight Admiralty three-drum small-tube type with a common closed furnace under forced draft.
 pressure 400 psi (28.12 kg/cm²)
 temperature 700°F (371.1°C)

Turbines four sets of the Parsons type with single reduction gears.

Shaft horsepower 130,000 overload (131,803 mhp) 120,000 normal (121,664 mhp)

Maximum speed 30 knots (designed)

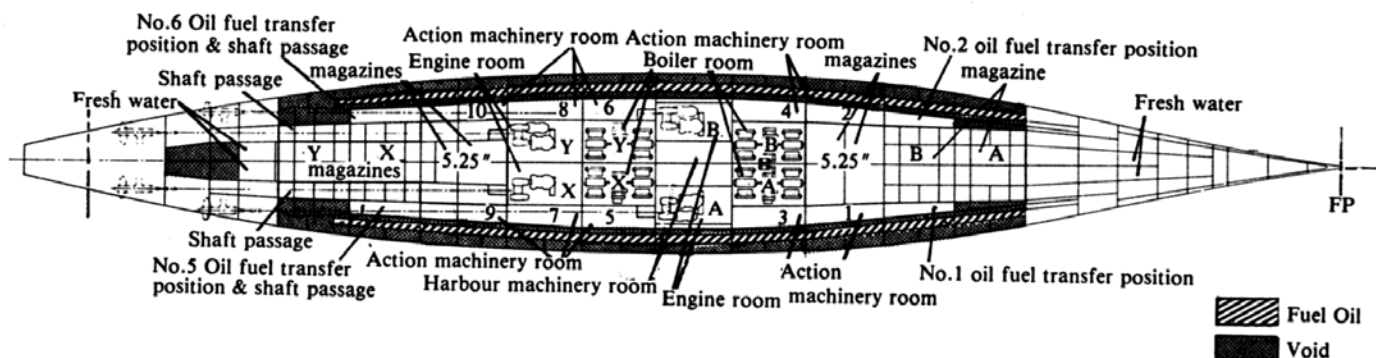
Trial speeds 31.57 knots at displacement of 45,720 tons (46,435 mt)
 30.38 knots at displacement of 51,070 tons (51,889 mt)

RPM 256.7 at 31.57 knots

Nominal endurance 5,500 nautical miles @ 12 knots
 3,380 nautical miles @ 28 knots

Generators four ship's service diesel generators (450 kw)
 four ship's service turbogenerators (480 kw)
 Total ship's service capacity (3,720 kw)

Machinery Schematic



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- Propellers** two five-bladed 14' 9" (4.50 m) diameter manganese-bronze propellers—outboard.
two three-bladed 14' 9" (4.50 m) diameter manganese-bronze propellers—inboard.
- Rudder** single balanced type with a projected area of the profile of 386 sq. ft. (35.86 sq. m.).

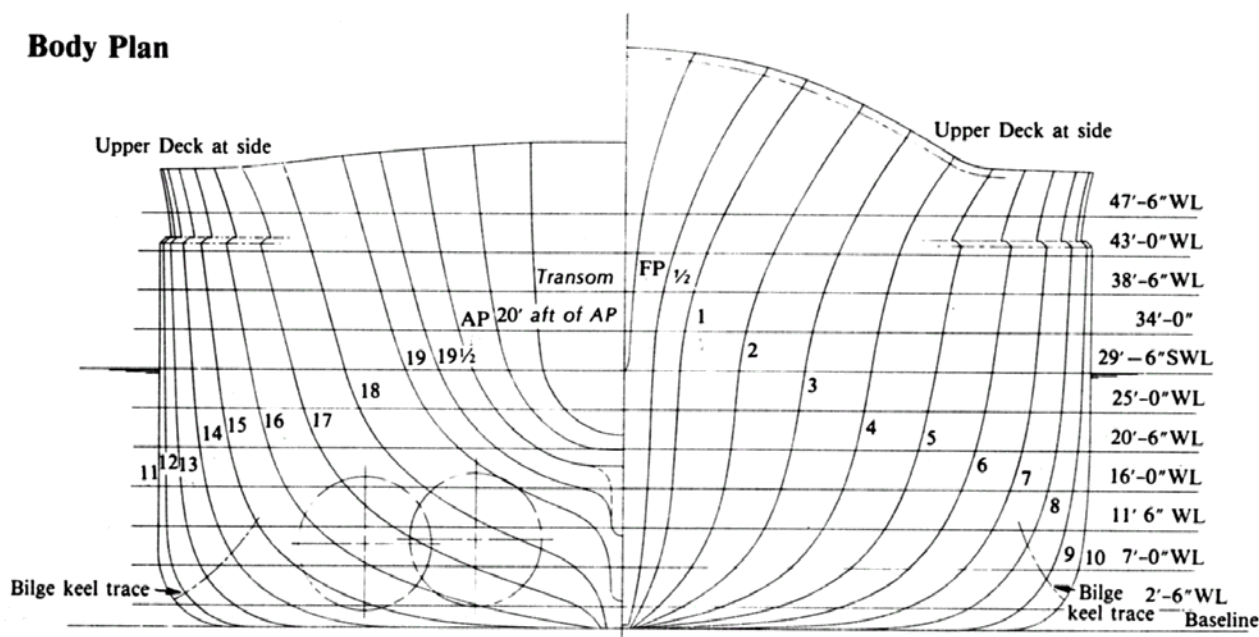
Miscellaneous

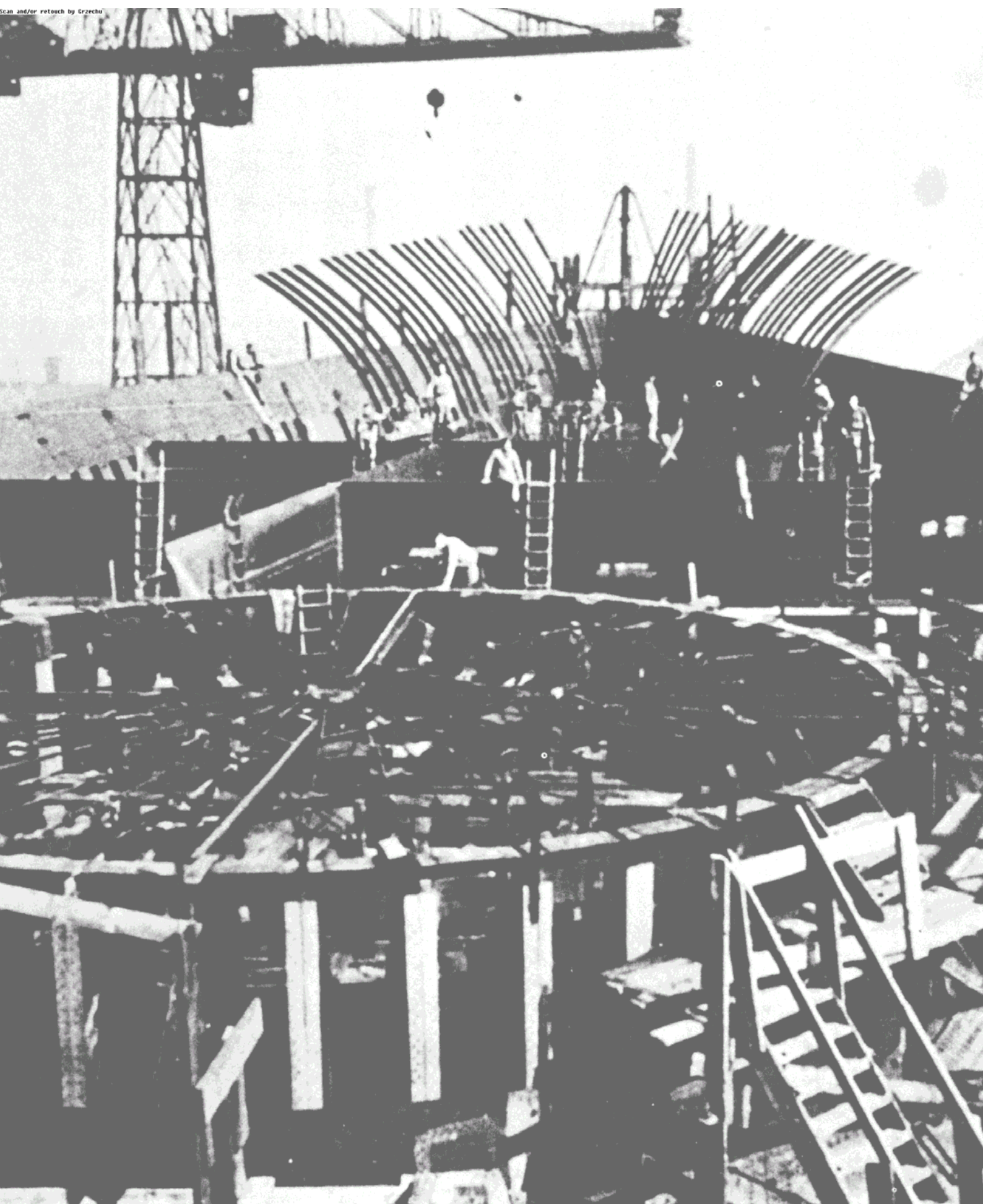
Complement	As Flagship		
	1,427	Design	July 1939
	1,453	Design	Feb. 1940
	1,600	Design	March 1941
	1,710	Design	Sept. 1942
	2,010 (128 off./1,882 enl.)		August 1946

Weights (1942)

hull	16,970	(17,243 mt)	38.2%
outfit	2,410	(2,448 mt)	5.4%
armor	15,350	(15,597 mt)	34.6%
machinery	3,150	(3,201 mt)	7.1%
armament	6,520	(6,625 mt)	14.7%
standard displt.	44,400	(45,114 mt)	100.0%

Body Plan





CHAPTER EIGHT

The Sovetskii Soyuz class

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If they had been completed, the Russian battleships of the *Sovetskii Soyuz* class would have been exceeded in displacement only by the giants of the Japanese *Yamato* class. Despite considerable difficulties, substantial progress was achieved in the construction of capital ships in the Soviet Union, although no ships were to be completed.

Background, 1925-32. The history of capital-ship design in the Soviet Union is only imperfectly known to the present, although sufficient information is available to confirm the enormous difficulties encountered by the Soviets during the 1930s as a consequence of the turmoil and bloodshed incident to the first two decades of the existence of the Soviet state.

As early as 1925, the Soviet naval authorities proposed that the strength of the Red Fleet should include eight capital ships and a total of sixteen cruisers. As the capital-ship inventory of the Red Fleet at that time consisted of only three dreadnought-type battleships, this would have required the construction of four additional capital ships and the completion of the battlecruiser *Ismail*, which had been launched on 22 June 1915.* Although this plan was rejected as being hopelessly unattainable, it is indicative of the Soviet interest in new capital ships for the Red Fleet.

Starting that same year, 1925, the Soviets began to receive considerable technical advice and warship construction assistance from the Italians. This substantial technical support effort included the design of the "D"-type submarines by the Adriatico firm, destroyer designs prepared by Odero-Terni-Orlando, and (most importantly) extensive collaboration with the Ansaldo firm.

Even before the turmoil that followed the Russian revolution in 1917, foreign assistance had played a major role in Russian warship design and construction. If anything, the need for such help was more acute after the communist seizure and consolidation of power.† The carnage and destruction caused by several years of particularly brutal civil war decimated the already modest Russian technical and industrial capabilities for warship construction.

* The hulk of the *Ismail* was scrapped about 1931. Three sister ships, the *Borodino*, *Navarino*, and *Kinburn*, also incomplete, had been sold for scrap in 1923. The full-load displacement of this excellent battlecruiser design would have been some 37,400 metric tons. These well-protected ships would have featured a main battery of twelve 356-mm/45-caliber guns and a maximum speed of 26.5 knots.

† The few dreadnoughts that survived the Russian Revolution had been designed by the Italians.

Foreign Technical Assistance. The most noteworthy factor in the years following 1932 was the energetic effort by the Russians to obtain technical advice and warship construction assistance from several major western industrial nations. At the very least, the technical products of this foreign assistance strongly contributed to the technological data base applied to Russian capital-ship designs.

Italian technical assistance. After a group of Soviet naval specialists visited Italy in 1933, Ansaldo received contracts for the construction of both warships and merchant ships. In return, the U.S.S.R. sold fuel, ore, and grain to Italy. During the next few years, Ansaldo completed the escort vessels *Kirov* and *Dzerzhinskii*, and the destroyer leader *Tashkent*, and also furnished equipment for the heavy cruiser *Kirov*, which was under construction in the Soviet Union.

Battleship design U.P. 41. Ansaldo completed a battleship design for the Soviet Union on 14 July 1936. Design "U.P. 41" was formally termed "Nave de Battaglia da 42,000 T. St." (battleship of 42,000 tons standard displacement).

Superficially, the design was a progressive development of the *Vittorio Veneto* class, resulting in a very powerful ship for a standard displacement of only 42,000 tons. Design "U.P. 41" had the following general characteristics, as compared to the *Vittorio Veneto*:

- Improved main-battery armament of nine 406-mm/50-caliber guns in triple turrets.
- Increased side armor protection; slightly improved deck armor. The general scale of armor protection was improved as compared to the *Vittorio Veneto*.
- A conventional multiple-bulkhead side protection system. The *Vittorio Veneto* design featured the unique Pugliese system.
- Increased power and maximum speed.

The impressive military characteristics given this design were probably the consequence of the acceptance of limited endurance and structural scantlings suitable only for operations in relatively sheltered waters. (Refer to Figure 8-1; details of the design are in Table 8-1.)

The Italians were most secretive about their novel Pugliese system of underwater protection.* The Ansaldo design for the U.S.S.R. did not include it, reverting to a conventional multiple-bulkhead side protection system design scheme. Several years later, when Dutch naval authorities visited ships of the *Vittorio Veneto* class under construction, the Italians were careful to keep their guests from learning of the Pugliese system. Despite this security, as will be seen later, the Soviets were well aware of the Pugliese concept.

It is probable that Design "U.P. 41" was delivered to the Russians, although there is no specific evidence of this. In any event, it seems certain that the design did not serve as the specific basis for actual construction.

American technical assistance, 1936-38. On 24 November 1936, the Russians requested that they be given permission by the United States government to negotiate with American firms for the production of heavy armor for battleships and cruisers. By

* This featured a large, hollow cylinder immersed in a liquid, either water or fuel. Refer to the discussion of the protection of the *Sovetskii Soyuz* for more details.

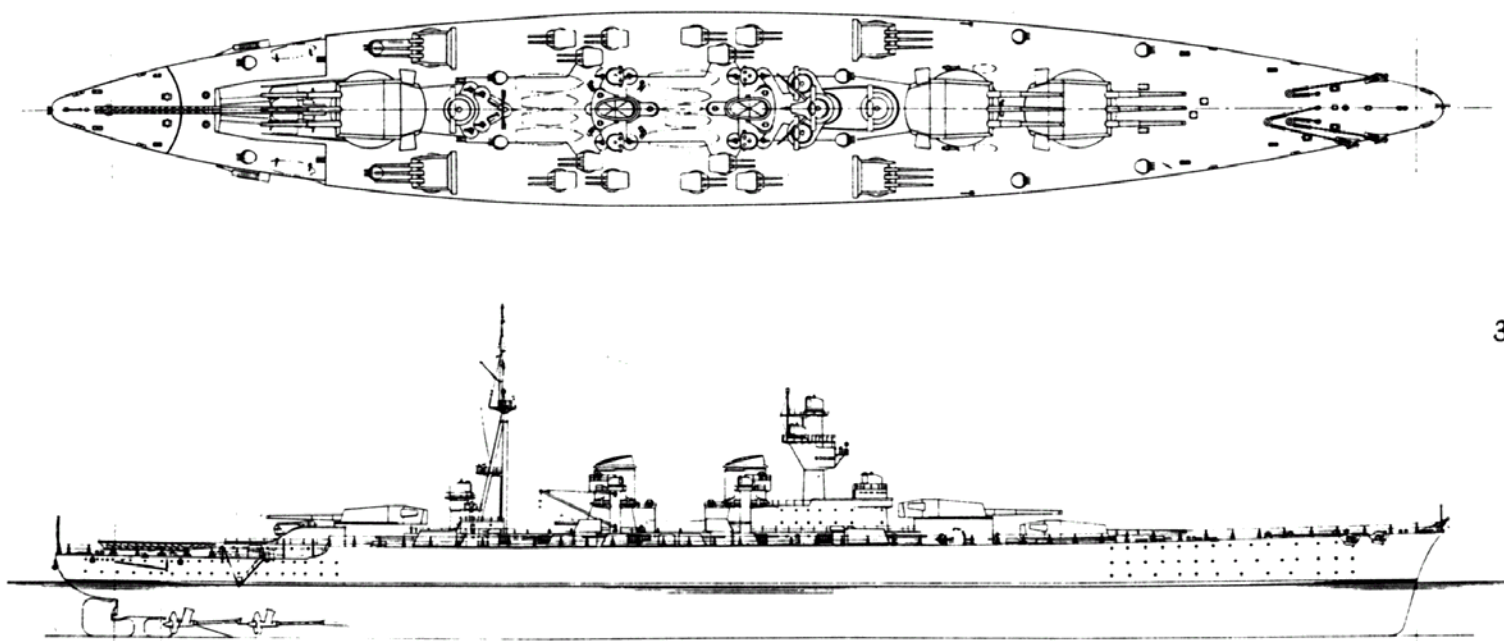


Figure 8-1. Ansaldo Design "U.P. 41"

1 October 1937, these efforts had expanded to the point that export permits were obtained for a total of nine 406-mm guns, 900 rounds of 406-mm ammunition, and three triple turrets for the 406-mm guns. Soviet efforts to contract for the construction of this equipment failed when commercial firms proved incapable of manufacturing it.

On 24 August 1937, the Russians approached the naval architectural firm of Gibbs and Cox, Inc., soliciting a design contract. After obtaining formal U.S. government approval, including arrangements for U.S. Navy security review of all plans prior to their delivery to the Russians, Gibbs and Cox concluded an agreement. During the next two years, that firm completed preliminary designs of ships for the equivalent of an entire carrier task force.

- *Battleship-aircraft carriers*: Three alternative concepts for imaginative, powerful new capital ships were prepared. These are discussed in more detail later in this chapter.
- *Battleship*: A conventional battleship design was also prepared. This is discussed in this chapter.
- *Destroyers*: Several designs were prepared of various destroyer-type ships, with displacements ranging from 914 to 2,450 metric tons.
- *Fleet oiler*: A high-speed fleet oiler design was also prepared.

Concurrent with the initial design studies, Gibbs and Cox negotiated with the Bethlehem Shipbuilding Corporation regarding capital-ship construction for the Soviets. The U.S. government had consented to such construction, provided that it conformed to treaty displacement limitations affecting U.S. warships. The Russians planned for one ship to be built in the United States, with a sister ship to be built in the U.S.S.R. No construction commitments resulted from these negotiations.

Gibbs and Cox project 10581. By November 1937, design work was well advanced on "Design A" and "Design B". These were similar studies of enormous battleship-aircraft carriers with a modest flight deck and capacity for approximately forty air-

TABLE 8-1
Ansaldo Design "U. P. 41"

<i>Design</i>	"U. P. 41"
<i>Date</i>	14 July 1936
Displacement	
standard	42,000 (42,674)
normal	45,470 (46,200)
Dimensions	
length overall	826.572' (252.000)
length between perpendiculars	774.275' (236.00)
maximum beam	116.469' (35.500)
normal draft	30.840' (9.400)
hull depth amidships	54.462' (16.600)
Armament	
main-battery arrangement	nine 16"/50 (406) 3-3-A-3
secondary (tripled)	twelve 7.1"/60 (180)
antiaircraft (paired)	twenty-four 3.9" (100)
machine gun (quad)	forty-eight 1.77"/45 (45)
machine guns (paired)	twenty-four 0.52" (13.2)
float planes	4
catapults	1
Armor	
main side belt	14.57" @ 6° (370)
lower side belt	none
upper side belt	5.91" (150)
turret face plates	15.75" (400)
turret sides	5.91" (150)
turret roof	7.87" (200)
barbettes	13.78" max. (350)
secondary face plates	7.09" (180)
secondary sides	2.36" (60)
secondary roof	3.54" (90)
antiaircraft face plates	3.94" (100)
antiaircraft sides	1.57" (40)
antiaircraft roof	1.97" (50)
conning tower sides	14.57" (370)
conning tower roof	7.87" (200)
main deck	2.16" (55)
second deck	0.39" (10)
third deck	0.98" (25)
fourth deck—inboard	2.56" + 1.38" (65 + 35)
fourth deck—outboard	2.56" (65)
fourth deck—slopes	1.38" (35)
Machinery	
boilers	8
shafts	4
shaft horsepower	177,538 (180,000)
maximum speed	32 knots

craft. The designs differed in armament, secondary battery disposition, and structural details (Table 8-2).

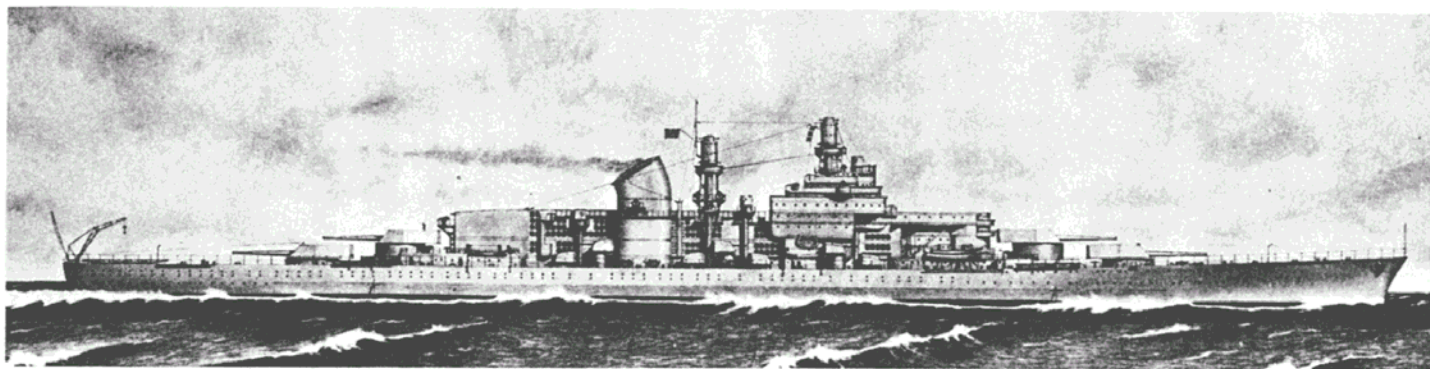
Technically, the most novel feature of these huge ships was the projected arrangement of six main propulsion shafts, providing a total of some 300,000 shaft horsepower, which would provide a maximum speed of 34 knots. The design provided for an enormous endurance, as much as 29,000 nautical miles at a cruising speed of 12 knots.

TABLE 8-2
Gibbs & Cox Designs A, B, and C

<i>Design</i>	<i>Design A</i>	<i>Design B</i>	<i>Design C</i>
<i>Date</i>	<i>November 1937</i>	<i>November 1937</i>	<i>July 1938</i>
Displacement			
light ship	...	58,800 (59,744)	44,200 (44,909)
standard	...	61,840 (62,832)	46,520 (47,266)
normal	66,074 (67,134)	71,850 (73,003)	55,200 (56,086)
full load	...	74,000 (75,187)	...
Dimensions			
length overall	1,000' 0" (304.800)	1,005' 0" (306.325)	845' 0" (257.557)
length waterline	975' 0" (297.180)	980' 0" (298.705)	820' 0" (249.936)
flight deck length	430' 0" (131.064)	402' 0" (122.530)	320' 0" (97.536)
maximum beam	126' 0" (38.405)	128' 0" (39.014)	118' 0" (35.966)
waterline beam	120' 5" (36.703)	120' 6" (36.728)	115' 0" (35.052)
normal draft	34' 4" (10.465)	34' 4" (10.465)	33' 4" (10.160)
hull depth amidships	56' 7" (17.247)	56' 10" (17.323)	54' 0" (16.459)
Armament			
main-battery arrangement	eight 18" (457) 2-2-A-2-2	twelve 16" (406) 3-3-A-3-3	ten 16" (406) 3-3-A-4
secondary (paired)	twenty-eight 5" (127)	twenty-eight 5" (127)	twenty 5" (127)
machine gun (quad)	twenty-four 1.1" (28)	thirty-two 1.1" (28)	... 1.1" (28)
machine gun (single)	ten 0.5" (12.7)	twelve 0.5" (12.7)	... 0.5" (12.7)
carrier planes	thirty-six	thirty-six	twenty-four
float planes	four	four	four
catapults	two	two	two
Armor			
main side belt	...	13" @ 15° (330) 7" lower edge (178)	...
turret face plates	...	16" (406)	...
turret sides	...	10" (254)	...
turret roof	...	7"-8" (178-203)	...
barbettes	...	15" (381)	...
conning tower sides	...	15" (381)	...
conning tower roof	...	8" (203)	...
secondary mounts	...	2.25" (57)	...
second deck (magazines)	...	4.75" + 1.25" (121 + 32)	...
second deck (machinery)	...	3.75" + 1.25" (95 + 32)	...
third deck (magazines)	...	1.75" (44)	...
third deck (machinery)	...	1.25" (32)	...
Machinery			
boilers	13	13	8
shafts	6	6	4
shaft horsepower	300,000 (304,161)	300,000 (304,161)	200,000 (202,774)
maximum speed	34 kts.	34 kts.	31 kts.
endurance	3,750 n. mi. @ 34 kts. 17,800 n. mi. @ 20 kts. 29,000 n. mi. @ 12 kts.	3,750 n. mi. @ 34 kts. 17,800 n. mi. @ 20 kts. 29,000 n. mi. @ 12 kts.	2,900 n. mi. @ 31 kts. 12,000 n. mi. @ 20 kts. 16,000 n. mi. @ 15 kts.
Complement	...	2,706 officers & men	...

"Design A" proposed a main battery of eight 457-mm guns in twin turrets, while "Design B" projected an armament of twelve 406-mm guns in triple turrets. "Design B" was chosen for further design development. Both design studies substantially exceeded the displacement limitations then in effect for U.S. capital ships.

As a result, when the U.S. government stipulation regarding the displacement limitations was received in June 1938, Gibbs and Cox proceeded to develop a displacement-limited battleship-aircraft carrier. "Design C" featured a reduced main



An artist's conception of the Gibbs and Cox "Design B" prepared in November 1937. Note the amidships flight deck—the superstructure above this level was offset to starboard, much like the "island" of a conventional aircraft carrier. (Gibbs and Cox)

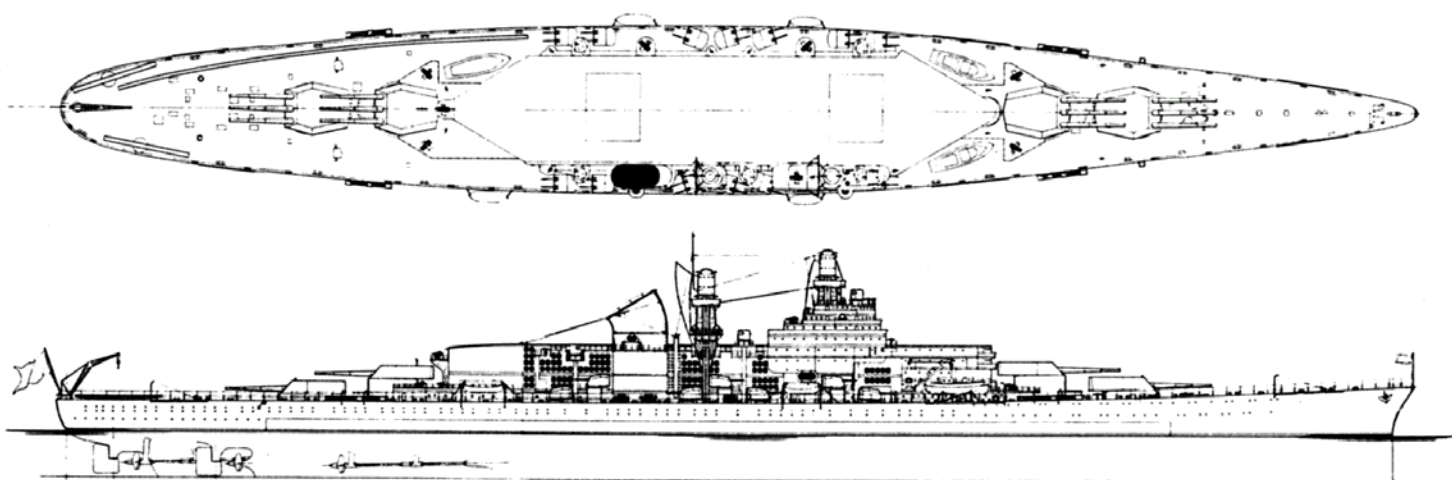


Figure 8-2. Gibbs and Cox Battleship Project 10581, Design B

battery of ten 406-mm guns, a much smaller air group, and a reduced maximum speed. (Table 8-2).

Czechoslovakian naval guns for the U.S.S.R., 1938. In August 1938 the Czech government and the Soviets came to an agreement that a Russian naval construction office should be established at the famed Skoda Works. The intent was that, with the assistance of Russian technical experts, Skoda would undertake the design and construction of naval guns for the entire Soviet Navy. Above all, 280-mm guns in triple turrets were desired, but Czech official archives also show Russian interest in 380-mm and 254-mm guns in triple turrets, heavy 120-mm antiaircraft guns, and smaller weapons.

Unfortunately, the capabilities of the Skoda Works were not commensurate with the firm's reputation. Skoda had formerly been the main supplier to the Austro-Hungarian Navy, as well as to foreign clients. After the Versailles Treaty, the French, in the course of providing technical, economic, and political "assistance" to the new state of Czechoslovakia, had seized the technical documentation for 350-mm guns (which had undergone proving-ground trials), as well as designs for new 380-mm and 420-mm guns. The completed 350-mm naval guns and the machinery required to

manufacture heavy guns were also seized by the French. By the end of 1920, Skoda did not have the capacity for manufacturing heavy guns.

As a result, Skoda was in no position to begin quickly the design and construction of the heavy guns most urgently required by the Russians. In any event, the crisis of the next few weeks led to the Munich agreement of 30 September 1938 between Great Britain, France, Italy, and Germany. The resultant German hegemony in Czechoslovakia caused the Russo-Czech naval collaboration arrangement to collapse.

Termination of American assistance, 1938-39. In November 1938, subsequent to security review and approval by the U.S. Navy, the further-refined plans of "Design B" by Gibbs and Cox were carried to Moscow for evaluation and consideration. The Russians found them to be unacceptable and indicated they were interested in the construction of a battleship along "conventional lines," well armored and armed with 406-mm guns. The Gibbs and Cox representative, a retired U.S. naval officer, was of the opinion that the Russians' chief concern was the acquisition of gunfire-control equipment and 406-mm guns complete with turrets needed for ships either projected or under construction. This information was relayed to the Secretary of State on 17 December 1938.

Gibbs and Cox Project 10901. A conventional battleship study, "Design D," was prepared by March 1939. This was a singularly attractive design, combining good speed, protection, and armament in a ship of some 45,000 tons standard displacement. Details of this design were discussed with a Russian naval mission in early March 1939 (Table 8-3).

On 9 October 1939, subsequent to the Russian invasion of Poland, Mr. William Francis Gibbs stated that, in view of the current situation in Europe, he would have nothing more to do with the project.* On 18 November, the Navy Department advised Gibbs and Cox that no plans or specifications should be delivered to the Russians, either in whole or in part. On 28 November, Mr. Gibbs commented that all he wanted was "to give the project a decent burial." So ended Russia's futile but intriguing efforts to obtain assistance in the design and construction of capital ships in the United States.

Resumed Italian technical assistance, 1939-41. Late in 1939, subsequent to the Russo-German rapprochement signaled by the "Non-Aggression Pact," which was concluded on 23 August 1939, the Italians resumed technical collaboration with the Russians.† This primarily involved assistance in the construction of the cruisers of the *Chapaev* class. This collaboration ended with the Axis invasion of the U.S.S.R. in June 1941.

* Germany invaded Poland on 1 September 1939. By 3 September, France and Great Britain had declared war on Germany. On 17 September 1939, in accordance with secret terms of their recent "Non-Aggression Pact" with the Germans, the Soviets also invaded Poland.

† This technical assistance, dating from 1925, had been suspended in 1938. Several factors had contributed to the strained relations between the two nations:

- Italy and Germany were allies. In 1938, the Germans were vociferous enemies of the U.S.S.R.
- The Russians and the Italians had supported opposing sides during the 1936-39 Spanish Civil War. Russian merchant ships carrying supplies to the Republicans were torpedoed by Italian submarines operating in support of the Fascists, led by General Franco.
- There were disputes regarding the delivery of Soviet oil to the Italian Navy.
- The Russians were alleged to have refused to pay some \$1,300,000 due on the construction of the destroyer-leader *Tashkent*.

TABLE 8-3
Gibbs & Cox Design D

<i>Design</i>	<i>Design D</i>
<i>Date</i>	<i>March 1939</i>
Displacement	
standard	45,000 (45,722)
normal	53,680 (54,441)
Dimensions	
length overall	845' 0" (257.557)
length waterline	820' 0" (249.936)
maximum beam	113' 6" (34.595)
normal draft	33' 4" (10.160)
hull depth amidships	56' (17.069)
Armament	
main-battery arrangement	ten 16" (406) 3-3-A-4
secondary (paired)	twenty 5" (127)
machine gun (quad)	sixteen 1.1" (28)
machine gun (single)	ten 0.5" (12.7)
float planes	four
catapults	two
Armor	
main side belt	13" @ 15° (330)
	7" lower edge (178)
turret face plates	16" (406)
turret sides	10" (254)
turret roof	7"-8" (178-203)
barbettes	15" (381)
secondary mounts	2.25" (57)
conning tower sides	15" (381)
conning tower roof	8" (203)
second deck (magazines)	5" (127)
second deck (machinery)	4" (102)
third deck (magazines)	1.75" (44)
third deck (machinery)	1.25" (32)
Machinery	
boilers	eight
shafts	four
shaft horsepower	200,000 (202,774)
maximum speed	31 kts.
endurance	2,900 n. mi. @ 31 kts.
	12,000 n. mi. @ 20 kts.
	16,000 n. mi. @ 15 kts.
Complement	2,010 officers & men

German assistance, 1939-41. The Russians also solicited German assistance, once the Soviet-German "Non-Aggression Pact" was concluded. A first German economic delegation arrived in Moscow on 8 October 1939. Initially, the Soviets requested plans for a battlecruiser of the *Scharnhorst* class and an aircraft carrier of the *Graf Zeppelin* class; shortly afterward they requested plans of the *Bismarck* and made numerous queries regarding the sale of military equipment.

A rather complicated trade agreement that was concluded on 11 February 1940 stipulated, in part, that the Russians would receive the incomplete heavy cruiser *Lützow*, plans of the battleship *Bismarck*, and heavy naval guns and turrets.

Although the Soviets expressed considerable interest in obtaining 283-mm guns and turrets, as well as 380-mm guns and turrets of the *Bismarck*-type, the Germans

eventually agreed to construct only eight twin-gun turrets and sixteen 380-mm guns for the Soviet Union. Construction of the guns and turrets was in progress on 22 June 1941 when Germany invaded Russia. Ultimately, the Germans abandoned work on the turrets, although the guns were completed and later used in coastal defense batteries.

Sovetskii Soyuz—Design Development. During the late 1920s, the noted Russian naval architect Alexei H. Krylov (principal designer of the *Sevastopol*-class battleship and a participant in the design of the *Borodino* class) prepared the preliminary design of a 33,000-ton standard displacement battleship with a length of 225 meters, a beam of 35 meters, and a design draft of 9 meters. The designed maximum speed was to be approximately 30 knots.

Other conceptual design studies are known to have been evaluated, including ships with the *Nelson*-type main-battery arrangement—all guns forward of the superstructure. Although there are indications that several studies evaluated ships armed with 406-mm guns in triple turrets, no further details are available regarding the characteristics of these design studies, their dates, and their relationship (if any) to the earlier Krylov design studies.

Several important factors markedly influenced the nature of Soviet capital-ship designs:

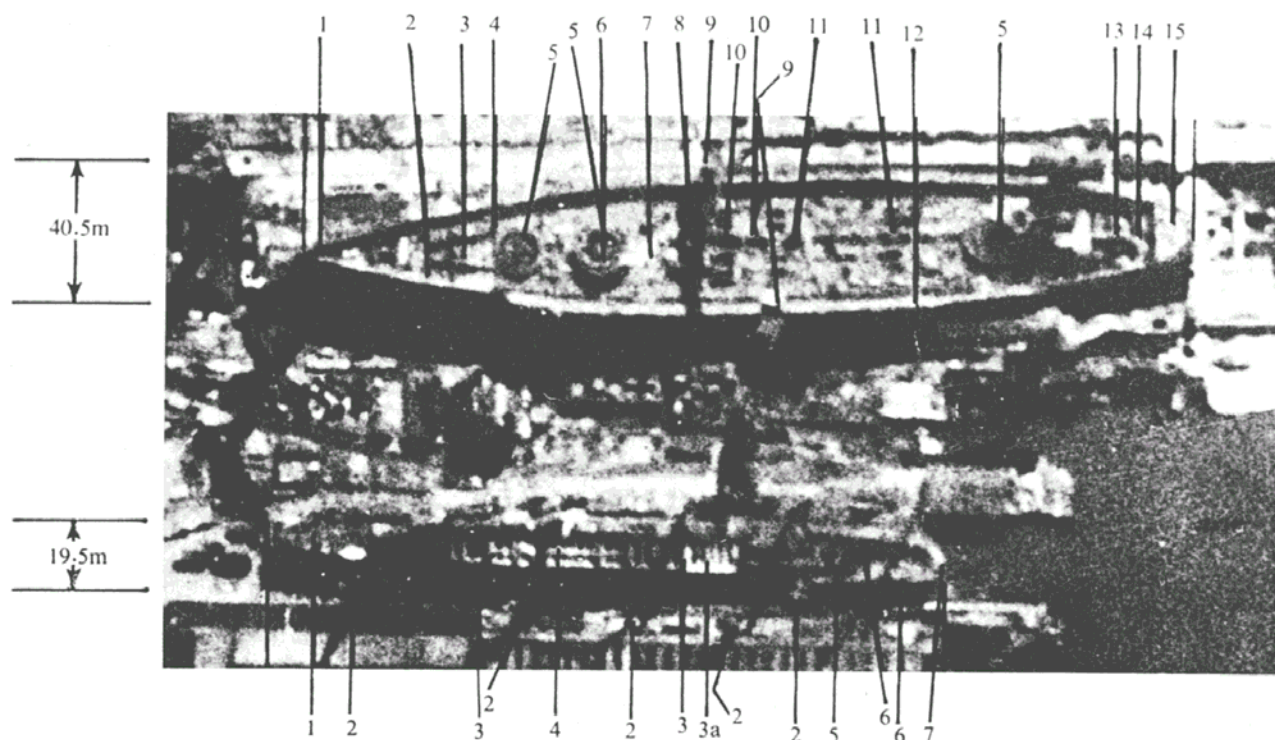
- There was *no* treaty displacement limitation on Soviet warships.
- Permissible drafts were severely limited by the relatively shallow depths of the Baltic and Black Seas.
- The Russian Navy, historically, had rarely ventured great distances from coastal waters. The most famous exception to this rule ended in the Russian naval disaster at Tsushima in 1905, and that epic cruise, after all, was to relieve the Russian garrison at Port Arthur.

The specific design evolution of the *Sovetskii Soyuz* class is not known, although available evidence on the characteristics of the battleships strongly suggests that the design was a Russian product, albeit strongly influenced by foreign technical developments (the Italian influence seems particularly apparent).

"Project 23," as the *Sovetskii Soyuz* design project was identified by the Russians, is believed to have had its inception about 1932. This date is supported by the known 1932 inception date for the heavy-cruiser design project that led to the construction of the *Kirov*-class. This project was designated "Project 26" by the Soviets.

A six-year interval between the initial design studies for a new class of capital ships and the laying down of the lead ship is long but not exceptional. This was particularly the case for the Soviet Union; the engineering, technical, and management personnel required for this major, complex project had minimal recent background in the design and construction of heavy naval ships. This problem, which was generally encountered by all the naval powers who constructed capital ships during the World War II era, was aggravated in the case of the U.S.S.R. by the long, sanguinary civil war which culminated in the establishment of the Soviet state subsequent to the end of World War I.

The final design of the *Sovetskii Soyuz* class, not surprisingly, reflected pronounced Italian influences in the arrangement and appearance of these ships. The Russian designers developed a very handsome battleship design, featuring a flush deck, a large forward superstructure-tower-mast configuration, two rather widely spaced



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German photo analysis of a July 1941 aerial photograph of Nikolayev. The battleship (Sovetskaya Ukraina) was estimated to be 264 meters long; the light cruiser (Ordzhonikidze) was known to be 201 meters long. (Rolf Erikson)

Top (battleship under construction)

Below (light cruiser under construction)

1. stem
2. deck beams
3. bow capstan installation with the capstan engine (located under the armored deck)
4. terminal bulkhead of the forecastle
5. cylindrical barbettes for the heavy (main) armament
6. support cylinder for the turret turntable (apparently already with training circle). The barbette reveals at its bottom the platform for the ammunition handling room.
7. battery deck (upper armored deck)
8. armored tube for the conning tower
9. two traveling pillar cranes
10. openings in the battery deck over the boiler spaces
11. openings in the battery deck over the turbine spaces
12. skin plating apparently with citadel armor (already in place)
13. steering engine room (the armored deck has not yet been extended over this)
14. tiller flat (same remark as for #13)
15. after (portion) of the upper deck (already plated in)

1. plating of the protective deck in the forward part of the ship
2. five fixed pillar cranes (also five on the starboard side)
3. watertight transverse bulkheads
- 3a. transverse bulkheads
4. longitudinal bulkhead
5. barbette armor foundation for the after turret
6. skin plating
7. elliptical stern



A 7 July 1941 German aerial photograph of the shipbuilding complex at Leningrad. The battleship *Sovetskii Soyuz* is shown at the Marti Works—number 1 (top, center). Number 2 (lower left side) identifies the battlecruiser *Kronstadt*, at the Marti Yard (Galernyi Island). (Rolf Erikson)

funnels, and a conventional main-battery disposition with two turrets forward and a single turret aft.

Table 8-4 presents the *estimated* characteristics of the battleships of the *Sovetskii Soyuz* class. This data represents an agglomeration of information gleaned from diverse sources. In general, there is now rather good agreement between available photographic evidence, data published in the Soviet naval literature, materials presented in Western and wartime naval journals, and postwar German and Allied naval intelligence reports. The data presented for the machinery plant differs substantially from information presented in other sources. The rationale and justification for this will be presented in the discussion of the propulsion plant.

The Soviet Council of Work and Defense authorized the construction of four battleships (the *Sovetskii Soyuz* class) on 21 January 1938.

TABLE 8-4

The Sovetskii Soyuz-Class—Estimated Characteristics

Displacement	
standard	59,150 (60,100)
full load	64,121 (65,150)
Dimensions	
length overall	889.108' (271.0)
waterline length	856.299' (261.0)
maximum beam	127.625' (38.9)
waterline beam	119.423' (36.4)
maximum draft	33.136' (10.1)
Armament	
main-battery arrangement	nine 16"/50 (406) 3-3-A-3
secondary (paired)	twelve 6"/50 (152)
antiaircraft	eight 3.9"/56 (100)
machine gun	thirty-two 1.46"/67 (37)
	eight 0.5" (12.7)
float planes	four
catapults	one
Armor	
main side belt	16.73" @ 8° (425)
turret face plates	19.49" (495)
152-mm turret armor	3.94" max. (100)
100-mm mount armor	3.94" max. (100)
conning tower	16.73" max. (425)
total deck armor	8.86" (225)
Machinery (estimated; see text)	
boilers	12
shafts	4
shaft horsepower	216,992 (220,000)
maximum speed	29 kts.
endurance	7,500 n. mi. @ 15 kts.

Sovetskii Soyuz—Disposition. The *Sovetskii Soyuz* was laid down 28 August 1938 on Slipway 7 of the Ordzhonikidze Yard (formerly the Baltic Yard) at Leningrad. The ship was assigned builder number 299. Production on the ship slowed down in early 1940, with work finally being formally suspended in October 1940. Officially, the cancellation was intended to release industrial capacity for more urgent work, but the decision was probably influenced by problems encountered with the production of guns and turrets. This inference is supported by the several years of strenuous Russian efforts to procure guns and turrets in the United States, France, Czechoslovakia, and Germany. In any event, industrial work on the ship had been suspended well prior to the German invasion in June 1941.

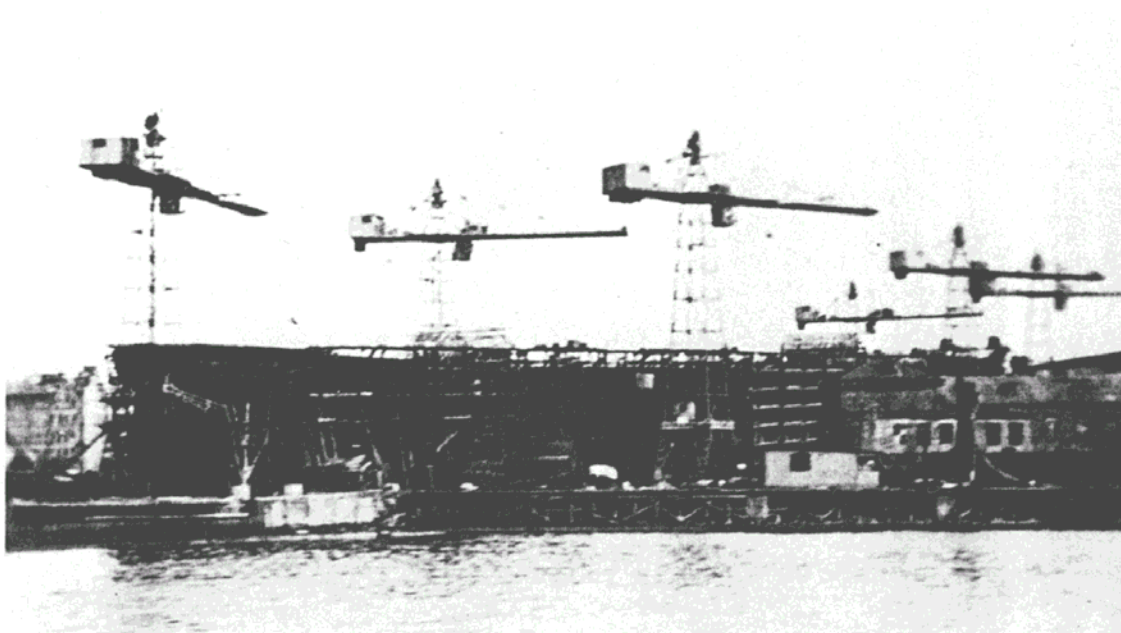
German aerial reconnaissance photographs of 5 July 1941 indicated that the hull construction was essentially complete, with the propulsion machinery installed and the armor deck in place. The ship was apparently almost ready for launching. German photographs in March 1943 confirmed the lack of further progress. Prisoner-of-war interrogations in 1944 indicated that much of the armor plating had been removed. By that time, the *Sovetskii Soyuz* was little more than an incomplete, rusting hulk.

On 29 June 1947, the U.S. naval attaché to Warsaw reported Swedish observations that the battleship *Sovetskii Soyuz* had not been worked on since the beginning of the war.



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A remarkable German detailed overhead view of the Sovetskii Soyuz, taken on 28 March 1942. The ship at the lower, left-hand corner is the light cruiser Chkalov. (Rolf Erikson)



The U.S. naval attaché photographed the Sovetskii Soyuz on 10 June 1944. The stern of the battleship is to the seaward end of the building ways. Note the similar heights of the scaffolding around the barbette structures for the second and third battery turrets.

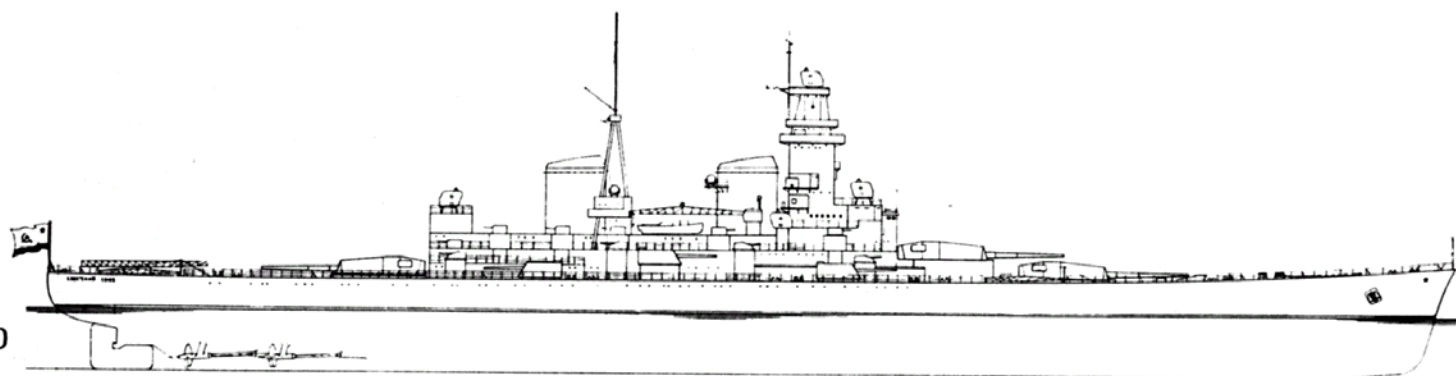


Figure 8-3. Estimated Appearance of Sovetskii Soyuz

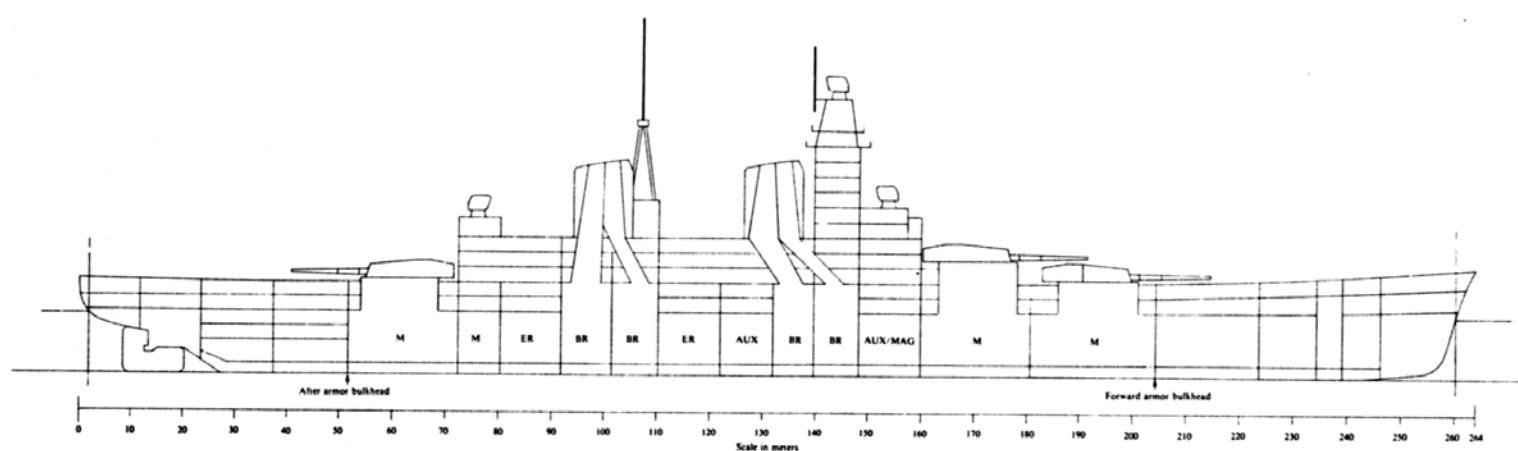


Figure 8-4. Estimated Inboard Profile of Sovetskii Soyuz

As part of the "Pussy Willow" Project, the Commander of the U.S. Naval Forces, Germany, obtained exhaustive interviews with repatriated German prisoners of war. According to this source, the *Sovetskii Soyuz* was dismantled during the period from April 1948 through April 1949. In the late summer of 1948, the dismantling slowed down with the stern still intact, and the plates for the cruiser *Sverdlov* were laid on the keel from amidships forward.

During late January 1949, the U.S. naval attaché observed the apparent scrapping of the battleship, as he noted ". . . ways contain the partially completed hull of what appeared to be a battleship." This interpretation was supported by observations made in May 1949 by the British naval attaché that the large slip, where *Sovetskii Soyuz* had been laid down, was apparently empty.

On 9-10 August 1949, the U.S. naval attaché saw one rusting after section of the hull on the ways of the large slip at the Baltic Works. Deteriorated scaffolding and cranes were in position, but no work was in progress. A section of this ship was observed at the Marti Yard, partially obscuring the view of the larger ways in that yard. Workmen were boarding the section up, possibly for winter preservation. Both sections were clearly observed to have a Pugliese-type side protection system. On 7 October 1949, no evidence of the battleship hull remained at the Baltic Yard.

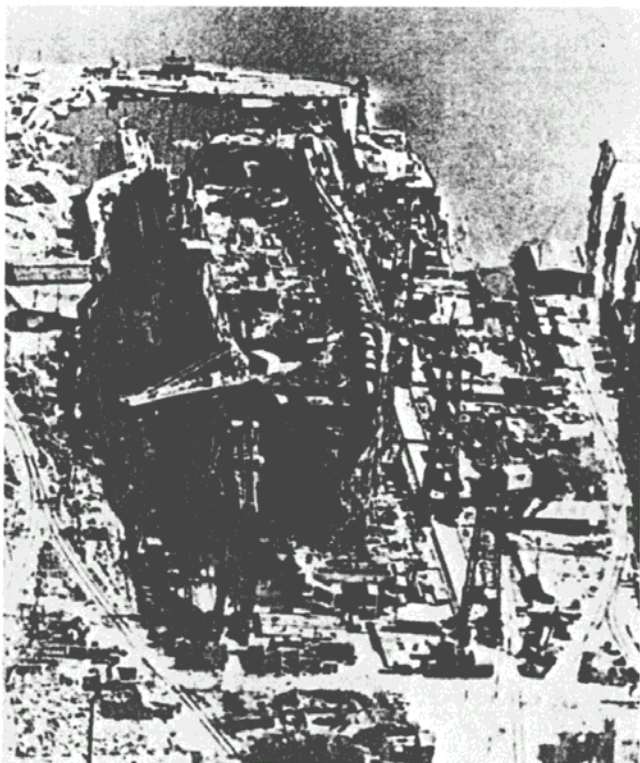
It is virtually certain that the hulk of the *Sovetskii Soyuz* had been scrapped by 1950.

Sovetskaya Ukraina—Disposition. The second ship of the class, the *Sovetskaya Ukraina*, was laid down at the Marti Yard, Nikolayev. (The Germans, in their wartime reports, referred to this as the South Yard). The battleship was assigned builder number 352 and was about 75 percent ready for launching, which had been scheduled for sometime in November 1942, when construction was suspended in October 1940.

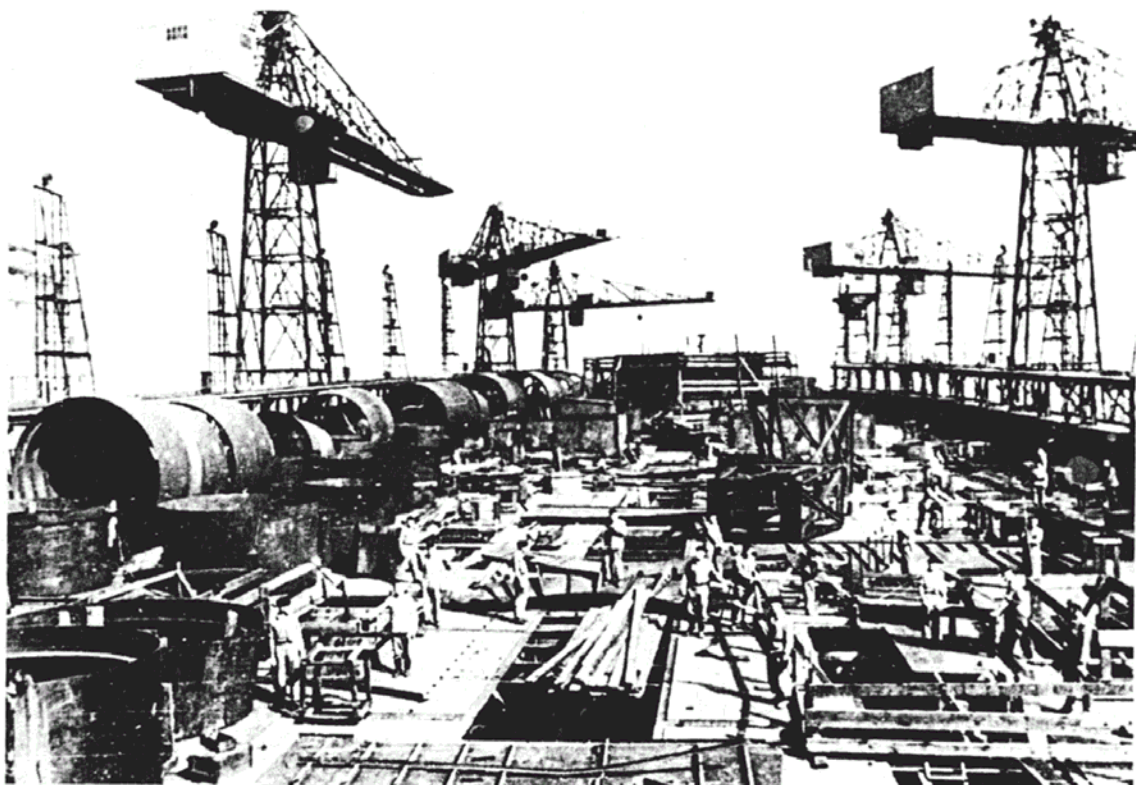
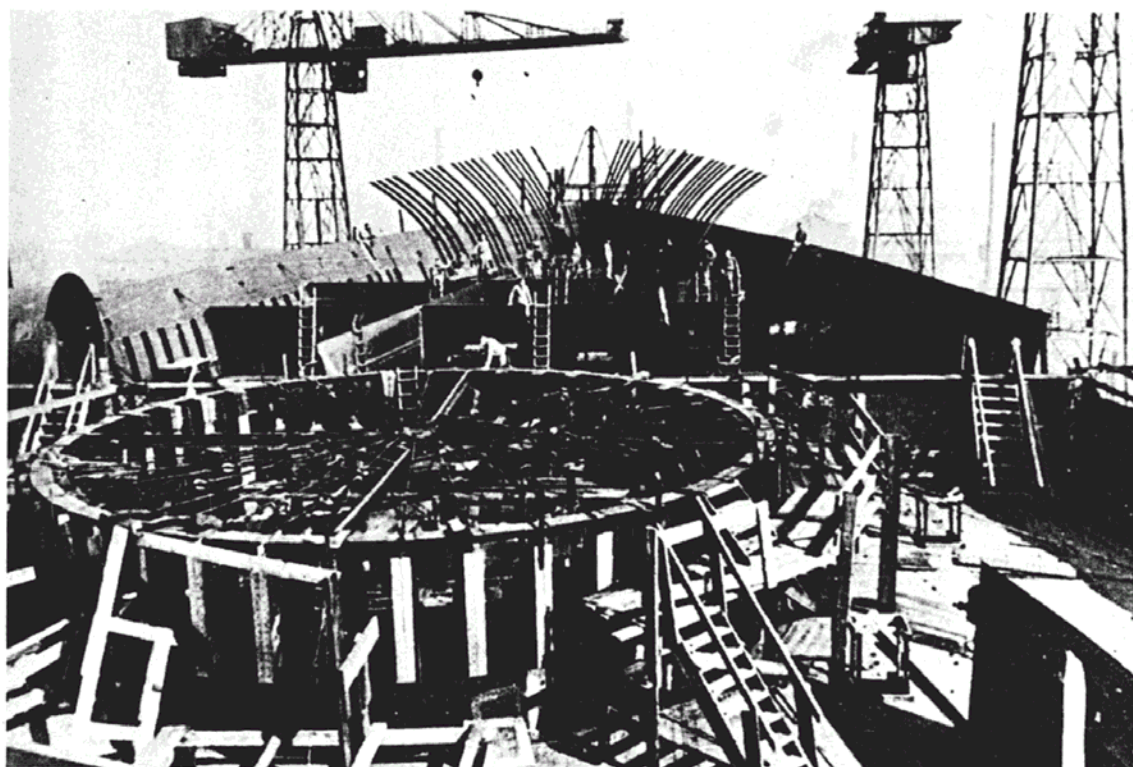
When German troops occupied Nikolayev on 18 August 1941, construction of the battleship had obviously been suspended for some time, as the upper deck was being used to store structural sections variously identified as either Pugliese System components or (more probably) as portions of submarine pressure hulls. According to Russians at Nikolayev, the ship was to have been towed to Sevastopol after launching, as the water depth at Nikolayev was insufficient for the ship after she had been fitted out.

Rear Admiral P. W. Zieb, German Navy, was in command of all captured naval facilities in the Black Sea area in 1944. On 17 March 1944, one day prior to the German evacuation of Nikolayev, the admiral was in the Marti Yards. Although the Germans had carefully prepared demolition plans for the shipyard facilities, the admiral noted that the army engineers apparently ignored them. In any event, the ways on the port side of the battleship had been dynamited, and the hulk was heeled over to port some 5 to 10 degrees.

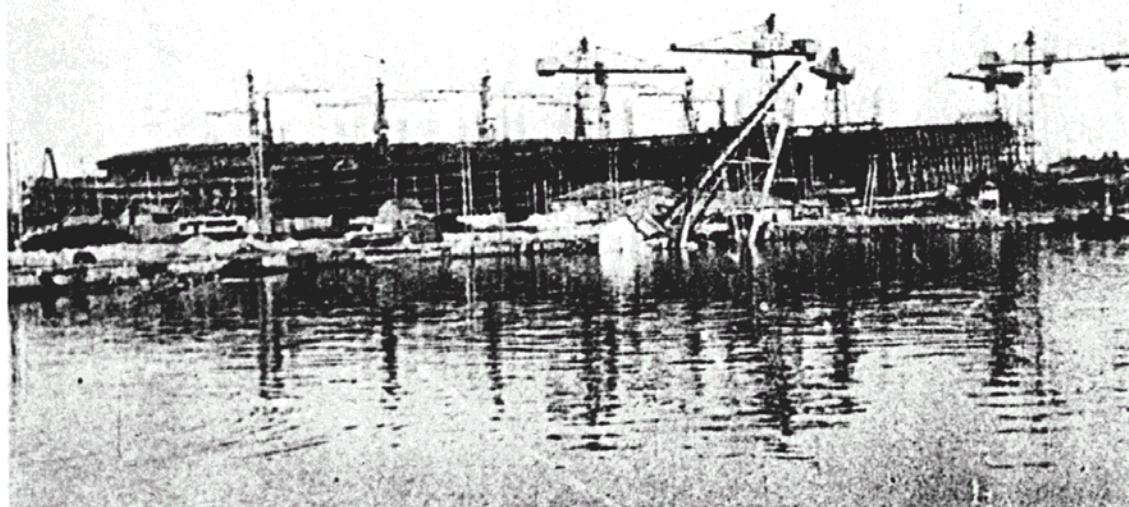
German demolition of the ways supporting the *Sovetskaya Ukraina* was confirmed by the reports of the Allied liaison officers who inspected Soviet Black Sea ports in June 1944. A yard official commented that “. . . the Germans had knocked most of the blocks from under the keel and it had settled beyond repair. Plans are to dismantle the hull for scrap.” The wreck of the *Sovetskaya Ukraina* was still on the slipway at the Marti Yards, Nikolayev, in May 1946. The hulk was apparently scrapped soon thereafter, as it was not seen in 1947.



The Sovetskaya Ukraina at Nikolayev in April 1942. The Germans had captured the hulk on 18 August 1941, almost a year after the Russians had suspended construction. (A. D. Baker)

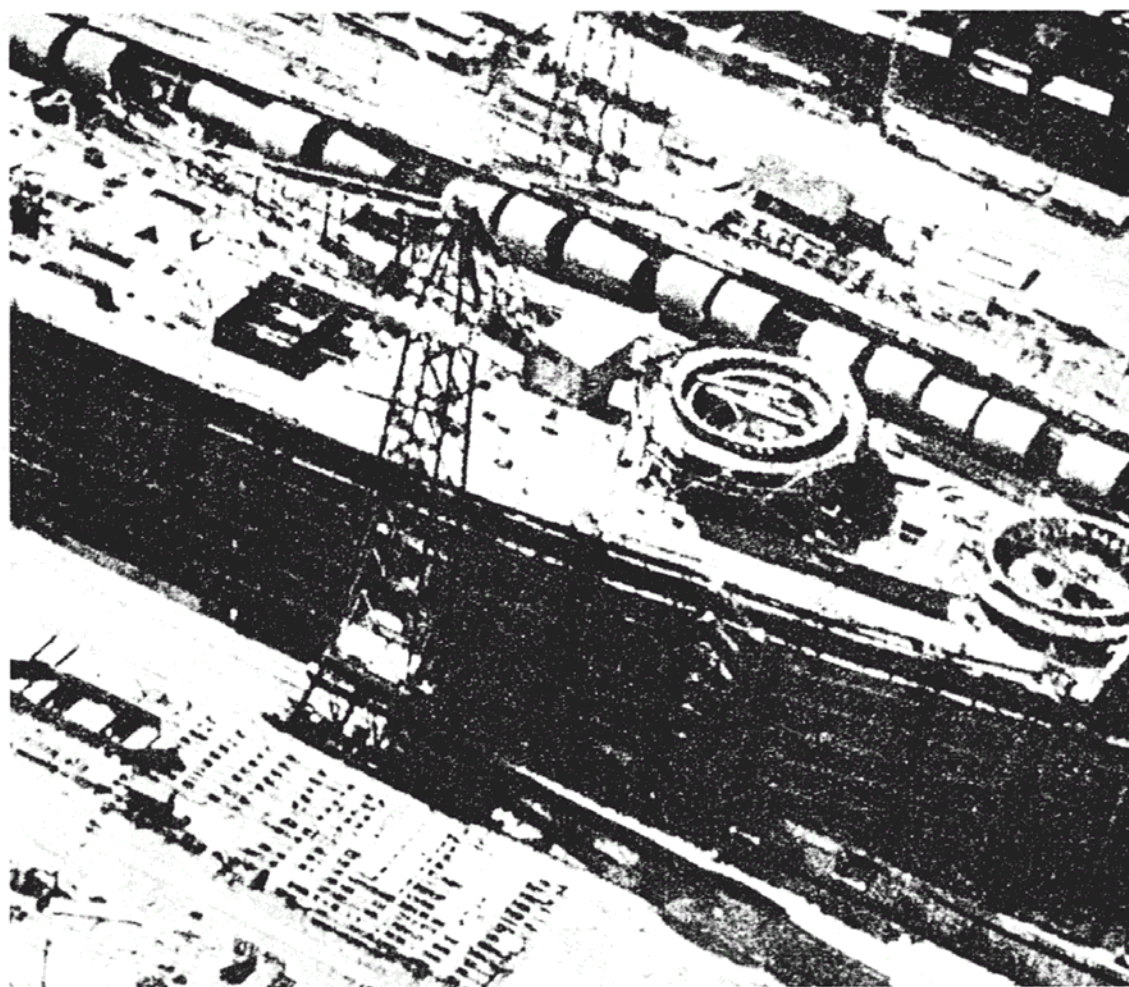


Two German views of the *Sovetskaya Ukraina*, both taken in September 1941. The top view is of the forecastle, taken from the forward edge of the number 2 barrette. The lower view, also looking forward, shows the amidships half of the ship. The cylindrical structures are believed to be submarine hull sections; the platform structures forward surround the forward main-battery barbettes. (Henri Le Masson)

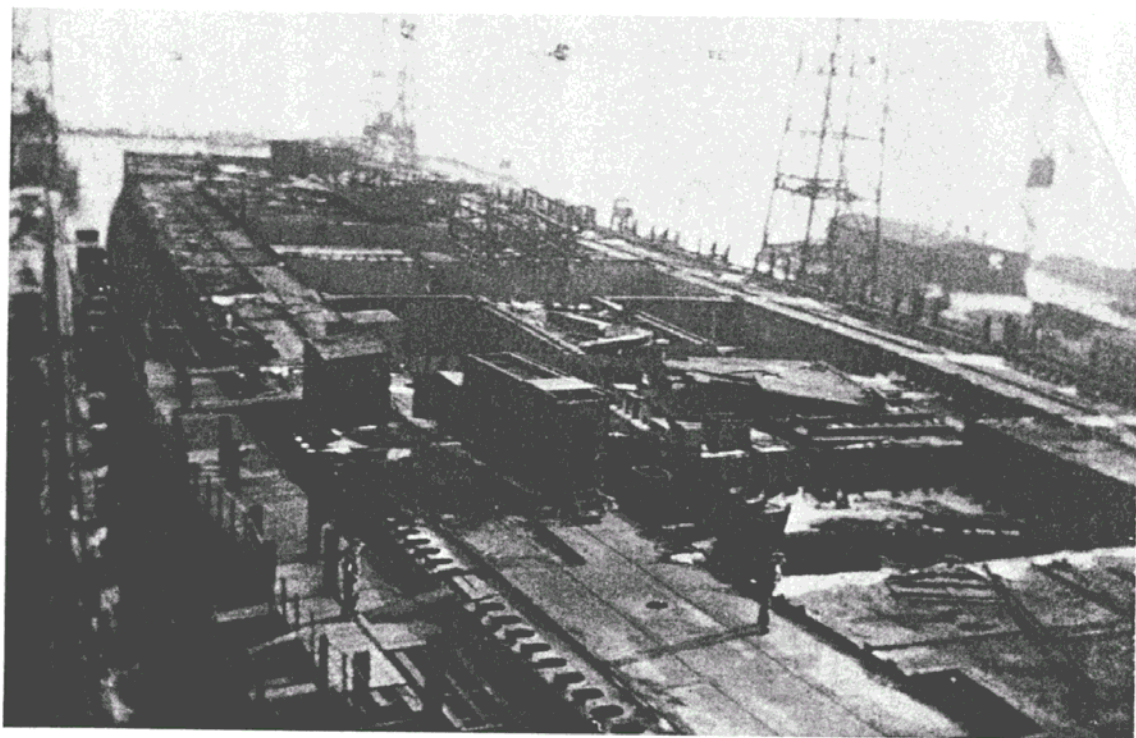


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A German September 1941 view of the starboard side of the Sovetskaya Ukraina, taken from the Bug River. Note the incomplete bow structure to the right. (Henri Le Masson)



An aerial view of the midships half of the Sovetskaya Ukraina. (J. Meister)



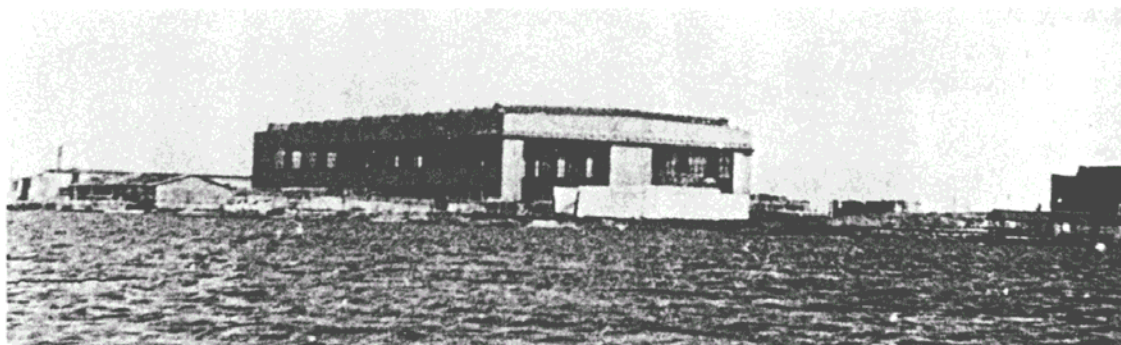
The last known photograph of the Sovetskaya Ukraina, probably taken during the winter of 1943-44. (S. A. Smiley)

Sovetskaya Rossiya and Sovetskaya Belorossiya—Disposition.

According to German sources, a new shipyard at Molotovsk, about 28 miles from Arkhangelsk, was begun in 1938-39. Some 120,000 forced laborers made sufficient progress that limited ship construction efforts could be begun in 1940. The facility was designed to become the largest warship construction yard in the world. Although a giant, enclosed 335- by 137-meter building dock had been completed, facilities were not available for steel bending or shaping. By the summer of 1941, ten main shops were erected, of which six were nearly complete. The facilities also included a double-enclosed graving dock, capable of destroyer or submarine construction, and nine open slipways. A total work force of some 35,000 to 40,000 was projected; actual wartime employment totaled about 5,000 people.

The final two ships of the *Sovetskii Soyuz* class were laid down in the enclosed battleship-building dock in 1940, with builder numbers 101 and 102 assigned. Apparently, the intention was to make use of considerable prefabrication of structural materials at Leningrad, transferring them by barge via the White Sea-Baltic Canal system, which had been completed in 1933. Similarly, materials were to be shipped by rail from Nikolayev in the Black Sea.

The *Sovetskaya Rossiya*, number 102, is believed to have been laid down in 1940. (Construction of this ship may have begun under the name *Strana Sovetov*.) As late as January 1944, the hull of this ship was observed in the dock at Molotovsk. The hull was an empty shell, incomplete even to the main deck. Construction had been suspended in October 1940, as was the case with the other capital ships.



Two views of the huge, enclosed battleship building dock at Molotovsk. Some 335 meters long by 137 meters wide, this structure could accommodate two battleships building side by side. Taken in June 1944, these views confirm the preparation for capital-ship construction. Light showing through to the right of the lower view confirms the limited progress attained in hull erection, as the hulk of one ship remained on the ways at that time.

The last ship of the class, presumably named *Sovetskaya Belorossiya*, number 101, was also begun at Molotovsk in 1940. The very limited structure that had been assembled when construction ceased in October of that year had been dismantled by the time the U.S. naval attaché visited Molotovsk in January 1944.

Floating Battery Number 3. During 1940-41, the Soviets used the prefabricated materials assembled for the two Molotovsk battleships to construct an experimental capital-ship hull section at Nikolayev. Later, this unit was armed and equipped as *Floating Battery Number 3*. Early in August 1941, the floating battery was towed to Sevastopol. Ultimately, the "Ne Tron Meniya" ("Touch Me Not"), as the Soviet sailors had nicknamed this craft, was beached in Kazach Bay during the final days of the siege of Sevastopol. The floating battery was abandoned there on 27 June 1942.

As *Floating Battery Number 3* was built using structural materials initially obtained for battleship construction, the history and characteristics of the battery constitute an interesting footnote to the history of Soviet capital-ship construction:

Dimensions	Armament	
Length	Two 5.1-inch (130-mm)	
Beam	Four 3-inch (76-mm)	
Draft	Four 1.46-inch (37-mm)	

Armament. The primary characteristics of the guns to be carried by the ships of the *Sovetskii Soyuz* class are presented in Table 8-5.

Main battery. The energetic Russian efforts to obtain foreign assistance in the design and construction of major-caliber guns and their turrets strongly indicate Soviet difficulties with the production of such guns. Although there is no specific evidence, it is highly likely that the Russians were concerned about their ability to construct such heavy guns after a hiatus in such work for more than two decades. Similarly, there may have been a problem in productive capacity, in terms of the number of such guns that could be constructed in a timely manner.

The new 406-mm/50-caliber gun is reported by the Russians to have had an outstanding range, as is indicated in the data tabulation (Table 8-5). Such performance for a 50-caliber gun of 406-mm bore is possible, for the U.S. Navy's 406-mm/50-caliber gun fired an appreciably heavier shell at a lower velocity to a maximum range of 38,720 meters.

One new 406-mm gun was apparently completed in time for gunnery trials early in 1940, with several more guns being constructed. Unfortunately, the gunnery tests were apparently unsuccessful, and the construction of additional guns was abandoned upon the outbreak of war. Turrets for the *Sovetskii Soyuz* had been completed by 1941, but they were never actually mounted on the ship. The expected rate of fire was 2.5 rounds per minute per gun. The sole 406-mm/50 gun to be completed was at the Naval Ordnance Yard, Leningrad, at the beginning of the war. The gun took the advancing German troops under fire on 8 August 1941, and apparently periodically engaged the enemy during the long siege of Leningrad. One of the shells for this gun is on display at the Central Naval Museum, Leningrad.

It is highly likely that the design of the new Soviet 406-mm gun was influenced by Italian ordnance technology. Two factors contribute to a high level of confidence in this conclusion:

- The Italians profoundly influenced contemporary Soviet cruiser designs.
- The claimed characteristics of the 406-mm/50-caliber gun, with a remarkably good maximum range, are consistent with the similarly noteworthy ballistic performance of the Italian 381-mm/50-caliber gun.

It is known that the Italian battleship guns attained their rather remarkable ballistic properties (firing a *heavier* shell than the *Bismarck* 380-mm gun to a *greater* range) at the price of a very modest barrel life, of the magnitude of 110-130 rounds.

TABLE 8-5

Gun Data

Gun	16-inch/50 (406 mm)	6-inch/50 (152 mm)
Shell weight (lbs)	2,443 (1,108 kg)	110.23 (50 kg)
Muzzle velocity (fps)*	2,800 (853 m/s)	3,003 (915 m/s)
Maximum range (yds)	49,869 (45,600 m)	30,085 (27,510 m)
Maximum elevation	*45°	*45°
Gun	3.9-inch/56 (100 mm)	1.46-inch/67 (37 mm)
Shell weight (lbs)	34.833 (15.8 kg)	1.587 (0.72 kg)
Muzzle velocity (fps)	2,953 (900 m/s)	2,887 (880 m/s)
Maximum range (yds)	26,247 (24,000 m)	8,749 (8,000 m)
Maximum elevation	85°	85°

* Data estimated.

This was less than half the norm for contemporary capital-ship guns. This was an economic and industrial penalty that the Italians willingly accepted in order to attain an important military characteristic. Needless to say, the relatively constrained theater of operations expected of Italian capital ships facilitated the decision process. The Russians, with similar geographic and operational constraints, apparently accepted the Italian gun-design rationale, and it is most likely, assuming the accuracy of the claimed performance data, that the Soviet 406-mm had a relatively short barrel life.

Secondary guns. The 152-mm/50-caliber gun, Model 1937, first actually entered service on the cruisers of the *Chapaev* class, which were completed in 1949-50. This was a very good, if not outstanding, cruiser gun with a normal rate of fire of some 7.5 rounds per minute per gun. Twin turrets of the type projected for the *Sovetskii Soyuz* never actually entered service in the Soviet Navy.

Antiaircraft battery. The 100-mm/56-caliber antiaircraft gun, Model 1934, was an excellent weapon ballistically, with an antiaircraft ceiling of 14,000 meters. The rate of fire was about 16 rounds per minute per gun. The same gun was used on the heavy and light cruisers laid down by the Soviets during the 1930s.

The 37-mm/67-caliber antiaircraft machine gun, Model 1939, had a rate of fire of some 100 rounds per gun per minute. Available data indicates sixteen twin mounts were projected for these battleships. The antiaircraft ceiling for this machine gun was 6,000 meters.

The projected armament of these battleships reflects the very marked Italian influences prevailing at that time on Soviet warship design practice. The adoption of a mixed secondary armament, with 152-mm guns for engaging surface targets and 100-mm guns for antiaircraft service, was typical of contemporary Italian and German capital-ship design practice.

Protection. Although only very limited technical data is available on the protection provided for the *Sovetskii Soyuz*, it is sufficient to indicate the massive scale of protection provided by the Russians for these large capital ships.

It is virtually certain that the entire protective scheme was designed in accordance with modern Italian practice.

The main side belt armor thickness has been specified as 425 mm. It is probable that this represented the total thickness of a sandwich system, such as was employed in the *Vittorio Veneto*-class battleships. The outer plate, likely some 100 mm, served to withstand the effects of high-explosive shellfire from cruiser-type guns while also tearing off the false cap from heavy armor-piercing shells. The main armor, about 325 mm, provided the basic ballistic protection. As in the *Veneto*, it is estimated that this armor system was inclined some eight degrees from the vertical. This was definitely excellent side armor protection, proof against 406-mm shellfire at all reasonable ranges.

Deck armor. The deck armor protection, with a total thickness of 225 mm, was very good, but not outstanding for ships of such great displacement. The distribution of the armor between decks was as follows:

Main deck	0.98 in. (25 mm)
Armor deck	5.91 in. (150 mm)
<u>Splinter deck</u>	<u>1.97 in. (50 mm)</u>
Total	8.86 in. (225 mm)

A more efficient distribution of the protection would have concentrated the armor thickness in the armor deck. Despite this arrangement deficiency, the deck armor protection was superior to that of most capital ships of the World War II era.

Turret armor. The armament was apparently to have excellent armor protection. Available data indicates that the 406-mm turrets would have face plates of 495 mm, while the 152-mm and 100-mm gunnery installations would have been shielded by armor of up to 100-mm thickness. Armor protection, however, for the main-battery turrets is not predicated by ballistic calculation. The face plate must be increased over its calculated thickness an indeterminate amount to compensate for the openings for the guns. The side plate is not usually calculated, and the rear plate is predicated by the requirements of turret balance. Only the turret roof is calculated ballistically, and according to other battleship design practices of foreign countries, its thickness was usually the same as the main armor deck. Therefore, the main-battery turrets for the *Sovetskii Soyuz* probably had the following thicknesses:

Face plates	495 mm
Rear plate	235-300 mm
Turret top	150 mm
Sides	225 mm

These thicknesses for the main and secondary batteries are indicative of a scale of protection that compares quite favorably with comparable foreign capital ships, such as the Japanese *Yamato* and the United States *Iowa* classes.

Conning tower. Maximum conning tower armor is stated to have been 425 mm, again a scale of protection that is indicative of generally excellent armor resistance against heavy shellfire.

Overall, the armor system projected for the *Sovetskii Soyuz* appears to have had the potential for truly excellent protection against heavy shellfire at normal battle ranges. In other words, Russian battleships of this class would have been formidable opponents.

Underwater protection. As was indicated earlier, these capital ships were provided with the Pugliese System of protection against torpedo attack. This system was devised by the Italians and incorporated in their new capital ships of the *Vittorio Veneto* class, as well as in the four old battleships which were thoroughly reconstructed in the years preceding World War II.

The Pugliese System featured a large, hollow cylinder that was designed to be immersed in fluid at all times. The concept was that the energy resulting from a torpedo detonation would be initially absorbed by the hydraulic crushing of this hollow cylinder, with further absorption of energy taking place by the turbulent action of the water/oil mixture in the added volume created by the crushing of the cylinder.

In service, the Italians found the system to be fairly effective against contact detonations, although its complex shape must have made the repair of battle damage particularly difficult. The loss of the battleship *Roma* revealed the vulnerability of the system to the near-miss detonation of large explosive charges. In general, the Pugliese System can be characterized as a relatively light but bulky system of demonstrated effectiveness against the contact detonation, but vulnerable to heavy noncontact explosions due to stress concentrations in the structure that joins the cylindrical system to the hull girder. Russian claims that these ships could withstand three torpedo hits on either side or two underbottom detonations are consistent with the available data on the great size and substantial protection given these battleships.

This thoroughly adequate side protection system, the heavy armor protection, and the powerful armament should have resulted in the construction of exceptionally battle-worthy ships, which would have been most potent adversaries in a gunnery engagement.

Propulsion Plant. Although published data has claimed the *Sovetskii Soyuz* would have had a three-shaft machinery installation giving from 210,000 to 231,000 metric horsepower, the authors are convinced for a number of reasons that a four-shaft Soviet power plant would have delivered some 220,000 metric horsepower.

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- The cruisers of the *Sverdlov* class, of similar design date, had some 55,000 metric horsepower per shaft.
- The marked Italian design influence, likewise reflected in the *Sverdlov*, would probably have resulted in similar technology for machinery installations on the Soviet capital ships.
- Marine engineering technology at that date rarely approached even 50,000 metric horsepower per shaft, much less than the 70,000 or so indicated by other sources. Even at the present, there are very, very few warships with as much as 70,000 metric horsepower per shaft.
- The great beam would readily permit a four-shaft arrangement, and photography supports this estimated configuration.

The *Sovetskii Soyuz*-class battleships are estimated to have had a total of twelve boilers arranged in four firerooms, each set of three boilers supplying steam to one turbine set. Similarly, the turbines are believed to have been located in separate engine rooms. The *Sverdlov* is known to have had three boilers per turbine set, and it is logical to conclude that the battleships of similar design vintage would have been given an identical machinery arrangement. These Russian cruisers were given a total of 55,000 metric horsepower per shaft.

The ships were probably provided with single reduction gears. A more complex gear would not have been possible in pre-World War II Russia. Moreover, single reduction gears were employed in British, German, Italian, and French capital ships of the same era.

It is probable that the steam turbine installation of these ships was designed to operate at pressures of the order of 25.66 kg/cm² and temperatures approximating 180° centigrade. Such modest steam conditions were typical of contemporary Soviet and Italian warships, and these relatively inefficient conditions further support the conclusion about the total power of the propulsion plant.

The broad, shallow-draft hull form and necessarily small-diameter propellers for such capital ships are not at all conducive to high propulsive efficiencies. High-power propulsive systems are often constrained by the onset of cavitation, which is influenced by the presence of high blade loadings. Propellers of a relatively limited diameter, such as would be required in these relatively shallow-draft ships, would tend to be subject to the onset of cavitation and would likely have difficulties with structural weakness.

All these factors, combined with the technological considerations discussed heretofore, would indicate strongly a metric horsepower rating of 55,000 per shaft.

Electric plant. No details are known of the electric plant. Based upon then-current European practice, however, it would probably have been a direct current type of some 230 volts.

According to Russian sources, a surprising endurance of 7,200 nautical miles at a speed of 15 knots was to be obtained. This performance, while not particularly noteworthy, appears rather large for ships designed for service in confined waters. Seemingly, the Soviets at the very least wanted their new capital ships to have the potential for ocean-going operations.

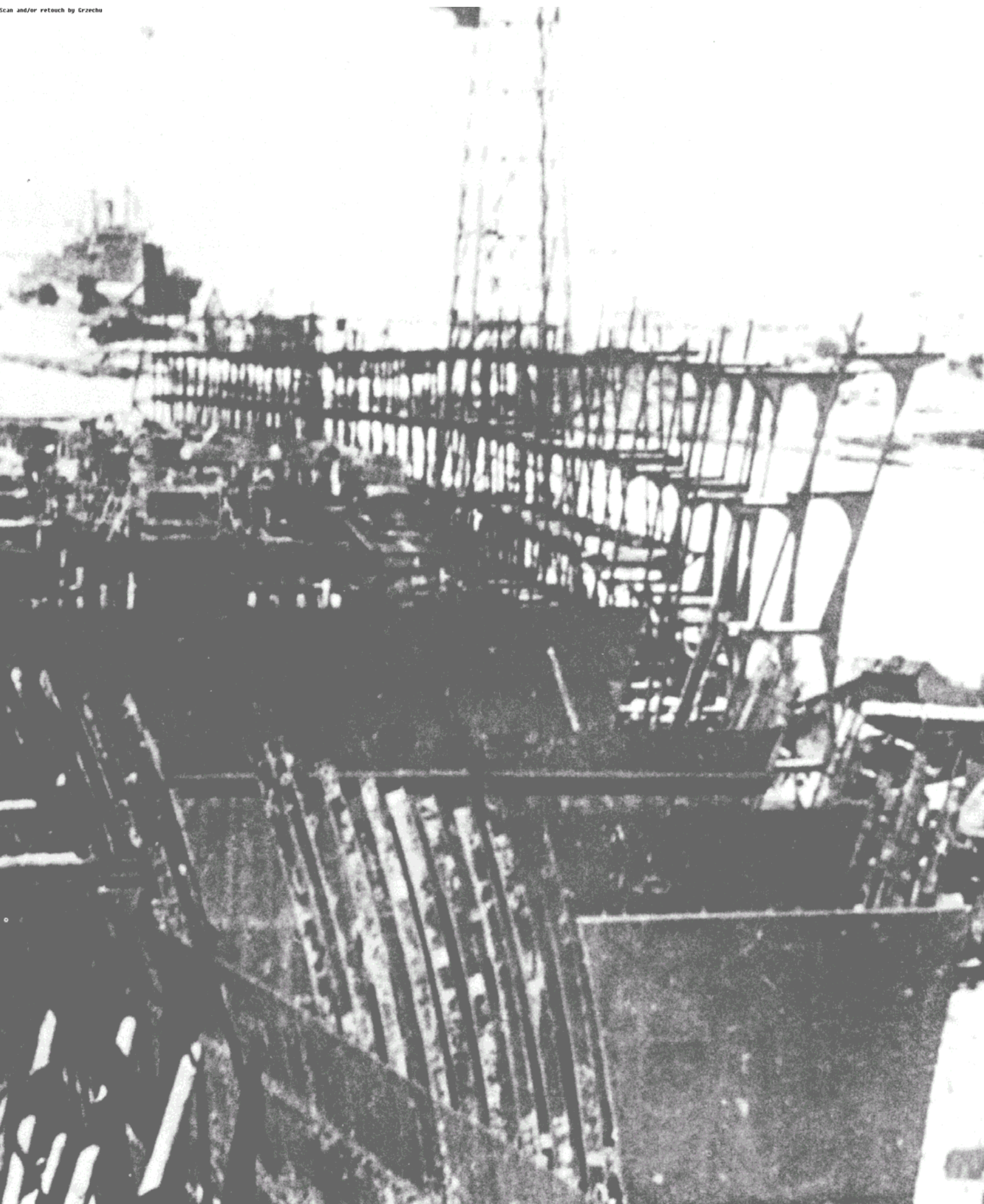
No details are known of the electric plant. Based upon then-current European practice, however, it would probably have been a direct current type of some 230 volts.

Hull Characteristics. Western naval officers examined the hulk of the *Sovetskaya Ukraina* at Nikolayev, observing the ship had a very unusual hull form, being roughly the converse of normal design practice. The bow portion of the hull was relatively full and broad, while the after part was sharply tapered. The stern configuration was observed to be "consistent with a triple-screw shaft arrangement."

Such an unusual hull configuration does not promise to be very efficient for high-speed operations. Similarly, a three-shaft configuration, when combined with a relatively broad, shallow hull form, would require the acceptance of propeller diameters that would be rather modest for such high power ratings. The authors believe the preponderance of evidence supports a four-shaft configuration for these ships. This is also a characteristic not indicative of an efficient propulsive arrangement.

Summary. It is difficult to evaluate fairly the characteristics of ships which never entered service, especially without access to accurate plans reflecting internal arrangements and structural configurations. Also, deliberations of a Ships Characteristics Board would be revealing as to the operations envisioned for such ships. None of this has been published by the Russians. In general, despite the heavy armament, good protection, and satisfactory performance, it is highly unlikely that such battleships would have made any material contribution to the Russian war effort.

In this regard, whatever the actual reason for suspending the construction of these battleships, when considering the actual course of the Russo-German War, it appears that the 1940 Russian decision to divert industrial capacity to other military projects was highly prudent and well justified.



CHAPTER NINE

Soviet Battlecruisers

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In 1953, at the time of the death of Joseph Stalin, two modern battlecruisers were under construction in Soviet shipyards. These ships were to be replacements for two earlier battlecruisers which had been begun before the outbreak of World War II. The saga of these two classes of capital ships, and the frustrations of Soviet building plans, both during the war and subsequently, are the subject of this chapter.

In 1936, when the construction of new capital ships to reinforce the Red Fleet was seriously being contemplated, the Soviets decided to develop both battleship and battlecruiser designs. This was all part of an ambitious program embarked on by the Soviet government to strengthen its navy and army.

The Kronstadt Class. A preliminary design of a battlecruiser primarily intended to engage 10,000-ton heavy cruisers armed with 203-mm guns was presented to the Soviet government for approval in July 1938. The basic characteristics of this design are outlined in Table 9-1.

TABLE 9-1

Characteristics of July 1938 Design

Displacement (standard)	22,637 tons (23,000 mt)
Main battery	Nine 10" guns (254 mm), tripled
Speed	33 knots
Belt armor	5.51" (140 mm)

As a result of this review, the basic design conception was rejected. Instead, the naval authorities were directed to develop designs of battlecruisers capable of engaging German ships of the *Scharnhorst* type.

Revised designs were submitted for approval in June 1939, but a series of detailed revisions and changes were necessary before formal government approval was granted on 12 April 1940, by which time two new battlecruisers were already under construction. The final design characteristics of the *Kronstadt* class are presented in Table 9-2.

Kronstadt—Disposition. The *Kronstadt*, name ship of her class, was laid down substantially in advance of the battlecruiser design's final approval. According to German sources, construction commenced in 1938, while Russian data

The battlecruiser Sevastopol, photographed by the Germans in August 1941 at the "61 Konemunar" Yard, Nikolayev. Work on the ship had been abandoned for almost a year by the time of the German capture of Nikolayev. (Rolf Erikson)

TABLE 9-2

Final Characteristics of Kronstadt

Standard displacement	35,240 tons (35,816 mt)
Full-load displacement	37,743 tons (38,360 mt)
Length overall	813.647 feet (248 m)
Waterline length*	787.399 feet (240 m)
Beam	103.018 feet (31.4 m)
Draft	27.558 feet (8.4 m)
Armament	Nine 12"/56, tripled (305 mm) Eight 6"/50, paired (152 mm) Eight 3.9"/56, paired (100 mm) Twenty-four 1.46"/67, paired (37 mm) Eight 0.5" (12.7 mm)
Aircraft	Four floatplanes, one catapult
Shaft horsepower	162,743 (165,000 mhp)†
Maximum speed	32 knots†
Main side belt	9.06" (230 mm)
Turret face plates	12.0" (305 mm)
Decks	3.54" (90 mm)

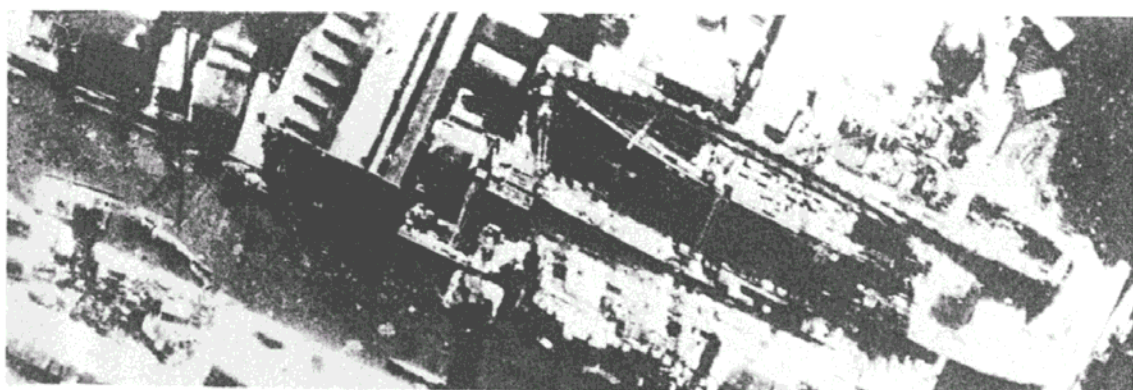
* Authors' estimate

† Estimated by authors; refer to text.

indicates a start date subsequent to June 1939 (the proportionate completion of the ship in 1940, when construction was abandoned, supports a late 1938 start date). In any event, despite the obvious Russian haste to begin construction, it appears first priority was given to battleship construction.

The *Kronstadt* was laid down on Slipway 4 at the Marti Yard, Leningrad, on Galernyi Island, during the winter of 1938-39. Early in 1940, an Italian engineer, assisting the Russians in the construction of the cruisers of the *Chapaev*-class, was advised by the manager of the Marti Yard that work on the *Kronstadt* had been suspended on 1 February 1940 because of the nonreceipt of 14,000 tons of steel plate and other materials. By October 1940, all work on new construction capital ships was abandoned by the Russians.

Shortly after the outbreak of war between Germany and the Soviet Union, German reconnaissance photography indicated that the *Kronstadt*, then erroneously identified as an aircraft carrier, was complete up to the bow. There was no further progress on



A remarkable view of the *Kronstadt* under construction at Leningrad. Note that the limited length of the building ways forced the separate construction of part of the stern structure on the starboard quarter of the ship. This would have been fitted to the stern structure once the ship was launched. (Rolf Erikson)

the construction of the ship, for the U.S. naval attaché estimated the ship was "five percent complete" when he observed the hull in June 1944.

Three years later, the U.S. naval attaché observed the *hull* to be about two-thirds complete during a 29 June 1947 visit to Leningrad. At that date, some work was apparently in progress, as a total of six gantry cranes were observed to be servicing the slipway, with a sling of flat plates being lowered into the hull.

During a 5-9 May 1949 visit to Leningrad, the British naval attaché observed no ships in the Marti Yard beyond the keel-laying stage of construction. On 9-10 August 1949, the U.S. assistant naval attaché observed workmen boarding up the stern section of the *Kronstadt*, presumably for winter preservation. Dismantling of the ship was apparently carried out during 1948-49.

The stern section of the *Kronstadt* was twice observed in Leningrad during 1950, but its ultimate disposition is unknown.

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Sevastopol—Disposition. A second unit of the *Kronstadt*-class, the *Sevastopol*, was laid down during 1938-39 at the 61 Kommunar Yard, Nikolayev. Late in 1941, the former German naval attaché to Moscow reported a "35,000-ton battleship" had been laid down at the "North Yard" (as the Germans termed the 61 Kommunar Yard), subsequent to his visit to the newly captured Soviet port city on the Black Sea.

Little is known of the disposition of this ship. The best available evidence is that the ship had been partially wrecked by Russian demolitions prior to the German occupation of Nikolayev, which took place on 18 August 1941. Apparently, the Germans partially dismantled the hull to obtain ship-repair and fortification materials. The partially dismantled hull was still at Nikolayev in June 1949. Ultimately, according to the evidence of a former Soviet naval officer, the hull was scrapped at Kamyslin Bay, Sevastopol, beginning in 1956.

Armament. Table 9-3 highlights the basic characteristics of the guns to be carried by the battlecruisers of the *Kronstadt*-class.

The new 305-mm/56-caliber gun, probably a Model 1940, allegedly had superb ballistic characteristics, as indicated by the data tabulated above. The onset of the war precluded the series production of the guns, which did not participate in the war.

TABLE 9-3
Gun Data

Gun	12"/56	(305 mm)	6"/50	(152 mm)
Shell weight (lb.)	838	(380 kg)	110.23	(50 kg)
Muzzle velocity (fps)	*2,900	(951 m/s)	3,003	(915 m/s)
Maximum range (yd.)	50,634	(46,300 m)	30,085	(27,510 m)
Maximum elevation	*45°		*45°	
Gun	3.9"/56	(100 mm)	1.46"/67	(37 mm)
Shell weight (lb.)	34.833	(15.8 kg)	1.587	(0.72 kg)
Muzzle velocity (fps)	2,953	(900 m/s)	2,887	(880 m/s)
Maximum range (yd.)	26,247	(24,000 m)	8,749	(8,000 m)
Maximum elevation	85°		85°	

* Data estimated.

During the Soviet trade negotiations with the Germans, they expressed strong interest in obtaining German triple turrets and 283-mm guns of the type given the *Scharnhorst* and *Gneisenau*, as well as twin turrets and a total of sixteen 380-mm guns of the *Bismarck* type. From this evidence, in view of the late date of final confirmation of the *Kronstadt*'s characteristics, it is particularly likely that a main-battery armament of nine 283-mm in triple turrets or six 380-mm guns in twin turrets was seriously considered for these battlecruisers.

Barbette diameters for the German 283-mm triple turrets and 380-mm twin turrets were sufficiently similar that conversion of the *Gneisenau* to a 380-mm armament was actually begun. In any event, the Soviets never actually received heavy guns from the Germans.

As has been mentioned earlier, German photo-interpreters mistakenly identified *Kronstadt* as an aircraft carrier. This error apparently resulted from the absence of barbette structures for the main-battery guns. As these heavy, bulky structures are normally erected relatively early in the course of hull construction, it is reasonable to conclude that the Russians reserved space in the hull structure and built around it, not having finally decided on the main battery (and the resultant barbette diameter).

The other guns projected for the *Kronstadt* were of the same type as would have been given the *Sovetskii Soyuz* class. Both the 152 mm and the 100 mm had very good ballistic performance, comparing favorably with foreign guns of similar caliber.

The adoption of a mixed-caliber secondary armament, which was typical of contemporary Italian and German capital-ship design, reflects the marked Italian influence on prewar Soviet warship design.

Protection. The armor protection given the *Kronstadt* was probably designed to withstand 28-centimeter shellfire. The limited available data presented in Table 9-2 is consistent with such a design requirement, which means the ships would have been particularly vulnerable to damage when engaged by main-battery guns of 356 mm or greater caliber, such as were carried by most contemporary capital ships. This vulnerability was characteristic of ships of the battlecruiser type, somewhat rendering them anachronisms in a period when truly fast battleships were being designed or constructed.

The pronounced Italian influence on Soviet warship design probably led to the incorporation of the unique Pugliese-type side protection system in the design of these battlecruisers. Certainly, a beam of some 31.4 meters would permit the installation of such a system, but only at the price of having a very "tight" machinery installation.

Propulsion Plant. As was explained in some detail in chapter 8, the authors doubt the validity of the Soviet claim of 231,000 metric horsepower for the machinery plants of the Soviet battleships and battlecruisers begun during 1938-39. Considering the beam of the battlecruisers, however, it is quite possible that similar machinery was provided for both capital-ship classes then under construction.

A total of 165,000 metric horsepower, provided by three shafts, would be sufficient to drive a ship of the displacement and proportions of the *Kronstadt* at a speed of about 32 knots.

Contemporary Soviet designs featured steam turbine plants with relatively moderate steam conditions, and it is almost certain that the battlecruisers would have been given comparable machinery. This, coupled with the relatively modest

fuel capacity implicit in the displacement data, indicates the *Kronstadt* likely would have had an endurance comparable to that of the *Sovetskii Soyuz* (7,200 nautical miles at 15 knots).

Electric plant. No details are known of the electric plant of these ships. However, based upon the then-current European practice, it probably would have been a direct-current type.

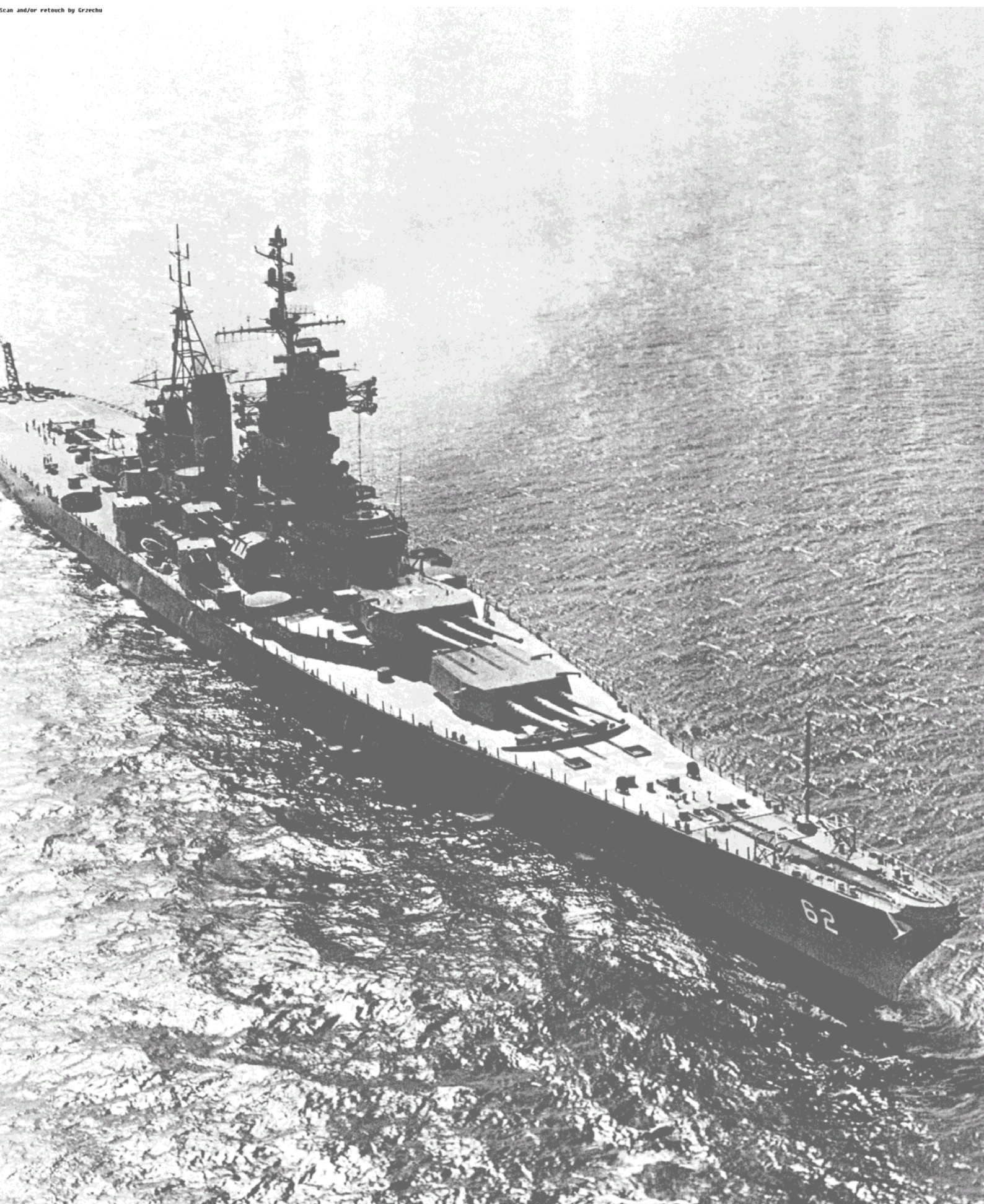
Summary. The *Kronstadt*-class battlecruisers would have been similar in general attributes to the American *Alaska* class, with a relatively powerful 305-mm gun armament coupled with good speed and hopelessly inadequate protection for ships of capital-ship size, no matter what their design requirements. As for the *Kronstadt*-class, it is most likely that any such Soviet battlecruisers would have been found to be of very limited value, had they entered service.

The Stalingrad Class. The frustration of the Soviet efforts to build capital ships prior to World War II, however, did not mean the end of the construction of ships of the battlecruiser type in the Soviet Union.

After the end of the war, Stalin's predilection with large capital ships prevailed again. Construction of at least one new battlecruiser of the *Stalingrad* class was begun in 1949 at Nikolayev. Little is known of its characteristics. Apparently, the ships were to have displaced some 32,000 to 34,000 metric tons, and it is assumed that the armament would have been similar to that of the *Kronstadt* design. However, the ship design would have followed German design practices, as the Russians had a number of German naval constructors and naval personnel under their control after the cessation of hostilities in May 1945.

The *Stalingrad*, the name ship of the class, was laid down at Nikolayev in early 1949, on the same ways where the *Sovetskaya Ukraina* had been erected some ten years earlier. By June 1949, some 80 to 100 meters of the midship portion of the ship, up to a height of some 10 meters, was in place. The battlecruiser was about 60 percent ready for launching in 1953. After Stalin's death, the project was canceled. The hulk was later launched, and eventually expended as a target for surface-to-surface missiles. A second ship of the class, probably to have been named *Moskva*, was reportedly scheduled to be laid down in the same building ways in which the *Stalingrad* was built. This would have taken place after the first ship was launched.

The Russian efforts to build modern capital ships were made difficult by the industrial and technological complexities inherent in such complicated projects. Extensive foreign technical and industrial assistance would have been necessary to the completion of the work. In any event, the nature of World War II naval operations indicate that such new ships, had they been available, would have been of limited value to the Russians during their desperate struggle to withstand the German onslaught of 1941-43.



CHAPTER TEN

Conclusion

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The capital ships constructed and projected by the Allied countries of World War II were different in terms of armament, arrangement, and protection. They reflected the different requirements sought by the naval staffs of each country. Capital ships involved long periods of construction, large outlays of money, material, and manpower, and required substantial shipbuilding and armor-producing capabilities. Therefore, only a few such ships could be constructed.

In France and Great Britain, capital-ship construction was the subject of heated debate. Nevertheless, Great Britain was to become the most prolific European builder of battleships, completing six ships out of a projected ten. An ambitious program for the reconstruction of the French fleet began in 1931; ultimately ten new capital ships were projected. By the time France fell to the Germans, two battlecruisers had been commissioned and two battleships were approaching completion.

In the Soviet Union and the Netherlands, ambitious construction programs were frustrated by the combination of limited resources and the onset of war. The main difficulty in Russia was the lack of sufficient industrialization, manpower, and experience, since the Russian civil war had devastated those yards which had built battleships, and it also had dispersed a highly specialized workforce. The Netherlands had an ambitious program for the construction of three battlecruisers, but the 1940 German invasion ended such a plan.

In all maritime countries, the naval staffs were convinced that the battleship and battlecruiser were not obsolete. The design and construction of such ships proceeded despite the objections of aviation advocates. Aircraft carriers were included in the naval programs of the major navies, but it was the development of better aircraft in 1939-42 that brought about the ascendancy of these ships over the battleship. Furthermore, only after Japanese air attacks crippled the U.S. battleship fleet at Pearl Harbor and sank the British *Prince of Wales* and *Repulse* in the South China Sea days later did emphasis begin to shift to aircraft carriers and aircraft as the prime exponents of sea power.

Almost all battleship construction was affected by some artificial limitation—whether it be shipyard, canal or harbor, fiscal, or treaty. Displacement restrictions resulting from the naval treaties of 1922 and 1936, plus the naval policy of the Royal Navy from 1927-34, were major factors in the development of British capital ships. France, unhappy about the limitations imposed on her battle fleet by the 1922 Treaty, withdrew from the 1930 London Naval Conference and finally abrogated this agreement in 1934. She was a signatory of the 1936 agreement, however, and maintained a policy of treaty compliance during the design of the *Richelieu*-class battleships. This philosophy resulted in major alterations to the original class design so that the stan-

The USS New Jersey (BB62) in 1969. Design studies have been made to modify the ship for modern-day warfare, retaining the main-battery guns for shore support. Studies were made in 1975 and as recently as 1980.

dard displacement could be maintained, yet the ships were to have the latest development in gunnery or protection. The Soviet Union was not a signatory of any naval treaties drawn up prior to the Second World War, so that the primary limitation on her capital ships was the water depths in Soviet harbors and estuaries, which were very shallow, forcing the adoption of large beams and proportionally shallow drafts. In the Netherlands, fiscal and industrial capabilities were major factors in ship size, armament, and equipment.

All designs were affected by improvements in technology; the most influential factors were increased ship speed and the improvements in weapons. In the late twenties and early thirties, it was anticipated by most naval powers that the value of high speed would increase during the lifetime of capital ships constructed during that period. This belief was reinforced by the progress made in marine engineering by the mid thirties, which permitted the installation of more powerful machinery of relatively lighter weight in much smaller spaces, as compared to the propulsion plants available at the conclusion of World War I. Also important at this time in the evolution of the battleship and the battlecruiser were the advancements made in torpedoes, mines, guns, and aircraft. Such developments made the inevitable design compromises even more difficult, since treaties limited the displacement of capital ships and imposed artificial limitations on the size of the main battery. Therefore, when design work commenced on battleships in 1933-34, a large proportion of their displacement (about 40 percent of standard) would have to be absorbed by passive defense—armor and underwater protection. In other words, the fixed displacement meant that the offensive armament would have to be decreased as the requirements for defensive armament, ship speed, and passive defense grew. For example, the *King George V* class mounted ten 14-inch guns in three turret positions with a power plant of 110,000 shaft horsepower, while the *Iron Duke* class of World War I mounted ten 13.5-inch guns in five turrets with a machinery plant of 29,000 shaft horsepower on a displacement roughly two-thirds that of the *King George V*. The French *Dunkerque* mounted eight 13-inch (330-mm) guns in two turrets with a propulsion plant of 103,860 shaft horsepower, while the *Bretagne*-class battleships of World War I mounted ten 13.4-inch (340-mm) guns in five turrets with a machinery plant of 28,560 shaft horsepower. In both the *King George V* and *Dunkerque*-class ships, the designers found it mandatory to combine the heavy antiaircraft and secondary armament into a single caliber to conserve weight and provide more guns.

Although substantial improvements in marine engineering technology permitted tremendous increases in installed shaft horsepower for less weight per horsepower, this technological benefit was much offset by the requirement for better (and heavier) protective systems against plunging attack (bombs and long-range shellfire) and underwater detonations (mines and, more importantly, torpedoes). Several developments led to this design crisis, which forced terribly difficult technical compromises between important military attributes (speed, endurance, gun power, protection, etc.), such as:

- Improved turret and gun design permitted the firing of heavier shells to longer ranges.
- More refined rangefinding devices and fire-control computers led to much-improved gunfire accuracy at long ranges.
- Improved aircraft designs made massive bombing and torpedo attacks a major threat.

These major new threats could only be dealt with at the cost of adopting improved (heavier and more expensive) systems of horizontal armor and more elaborate

torpedo-defense systems. Deck-armor systems were easily twice as thick as in most dreadnoughts of the World War I era, while the progressive increase in the size of torpedo charges resulted in the adoption of deeper and more elaborate side protective systems. The threat of bomb and shell splinters and fragments and aircraft machine-gun strafing attacks on the topsides of a capital ship with large exposed vital areas, led to the use of extensive splinter protection. In general, new post-treaty capital ships were more heavily protected, had greater hitting power per gun (but in some instances fewer guns), and were much faster than comparable ships built during the World War I era.

France. Although France had been assigned a total displacement of 175,000 tons for her battle fleet under the terms of the Washington Treaty and had received permission to construct a new ship in 1927, it was not until 1931 that the French Navy was finally able to obtain the funds to construct their new capital ship.

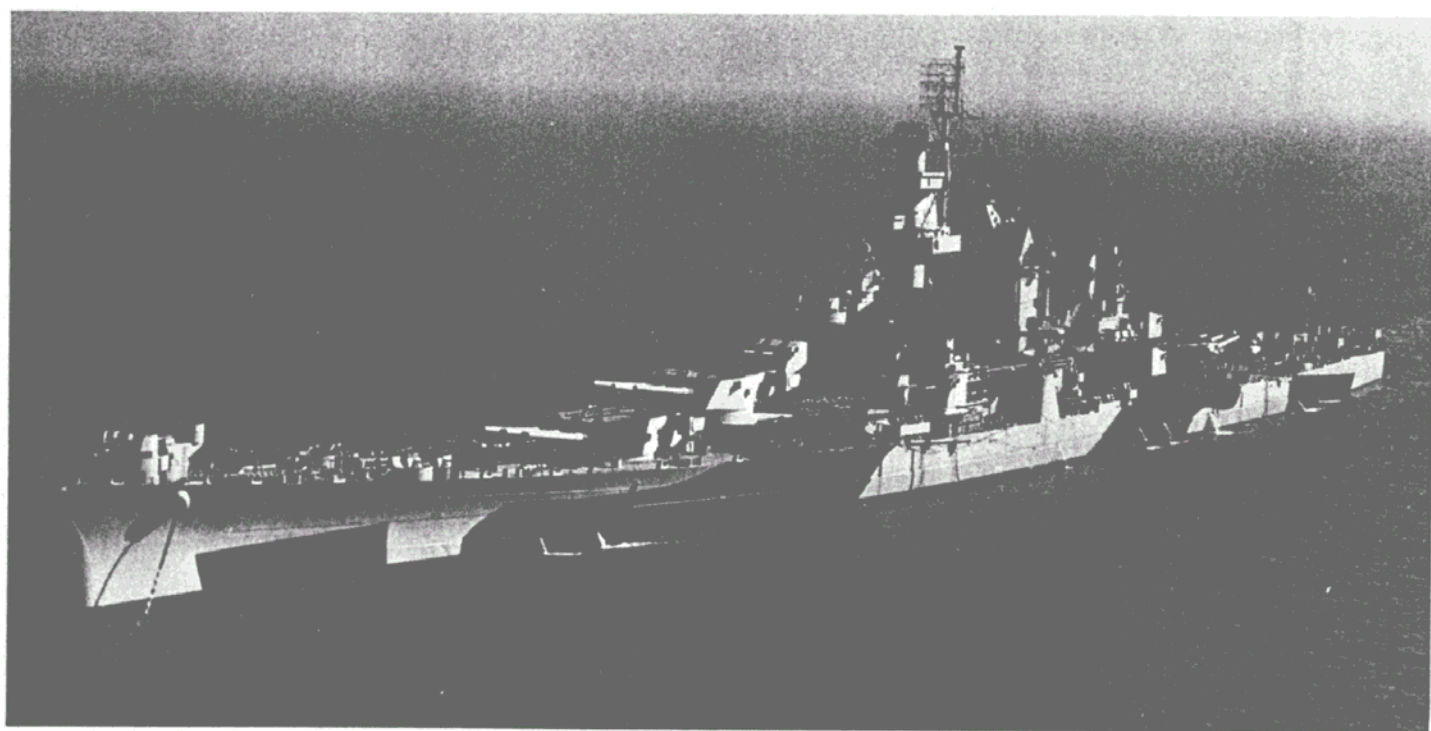
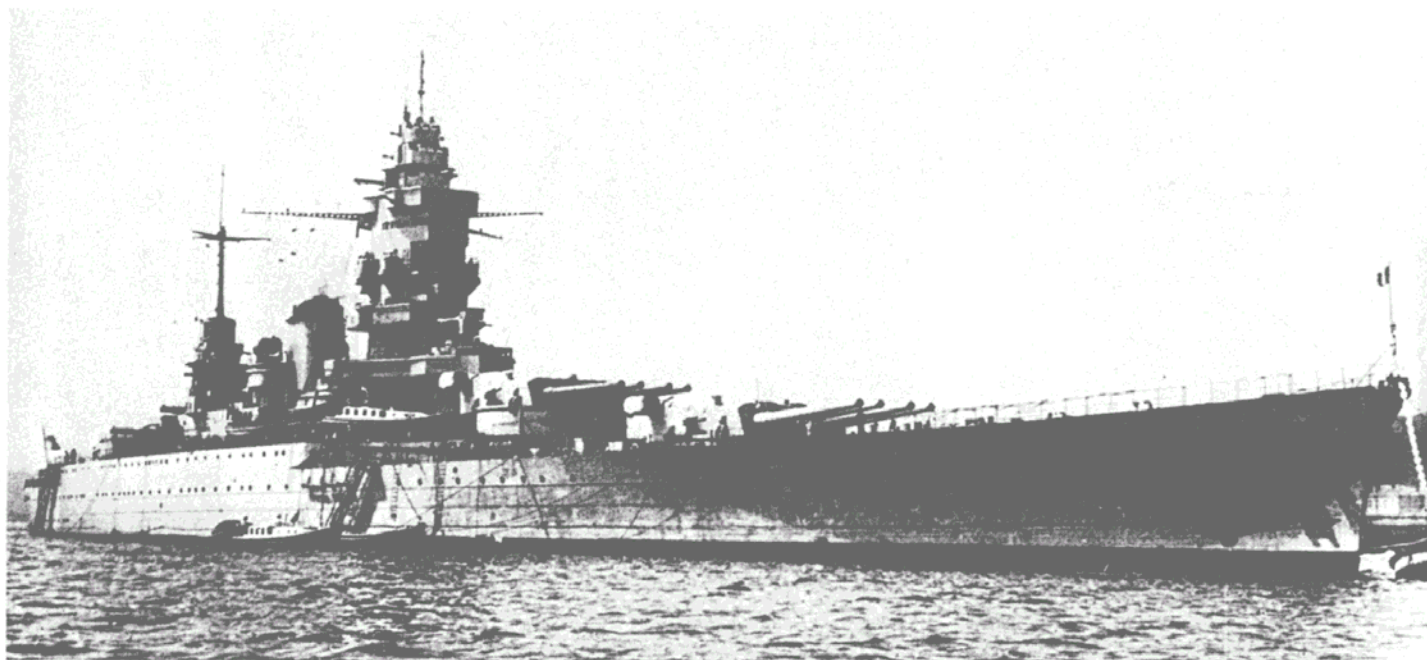
The battlecruiser *Dunkerque* was the first of a new-type battlecruiser featuring high speed, a modest main-battery gun bore, and relatively weak side armor protection. The latter deficiency was corrected in her sister ship, the *Strasbourg*. These ships had a unique arrangement of their main and secondary armament and a very formidable underwater protection system for a standard displacement of less than 30,000 tons. This combination was achieved by limiting the armor protection, the adoption of a compact, light, and powerful propulsion plant, and the concentration of all the main-battery and most secondary guns into quadruple turrets.

The *Dunkerque* was an excellent example of the traditional battlecruiser, featuring excellent speed and good gun power, but relatively weak side armor protection. With substantially improved armor, her sister ship, the *Strasbourg*, was perhaps the best protected battlecruiser ever built. Both ships were armed with 330-mm guns—the heaviest main battery ever mounted in a completed modern battlecruiser—and one of the most powerful secondary armaments. They also had the best underwater protection for a battlecruiser, and in this respect even surpassed some battleships of larger displacement. This system was proven in underwater explosion tests and under combat conditions when the *Dunkerque* sustained severe underwater damage in July 1940.

France, faced with an Italian battleship modernization program during the early thirties and the announcement by Benito Mussolini of the construction of two 35,000-ton battleships in 1934, began the design of its own 35,000-ton battleship in June 1934. Speed, protection, and gun power were all important considerations in the design. To achieve a balance between these and yet attain a 35,000-ton displacement, the propulsion plant and main battery had to be concentrated. This also led to a main battery in quadruple turrets in an arrangement similar to that of the *Dunkerque* and *Strasbourg*. With this unorthodox disposition, the armored citadel was minimized and the main battery located in a portion of the hull where there would be more underwater protection than in a four- or three-turret battleship. Emphasis was also given to antiaircraft and surface defense. As the aircraft menace grew in the late thirties, the armament arrangements of each *Richelieu*-class battleship reflected a new philosophy in the antiaircraft defense for a capital ship. Finally, it became necessary to alter the main-battery disposition equally forward and aft to provide adequate antiaircraft coverage and minimize the blast effects of the 152-mm and 380-mm guns on antiaircraft gunnery operations.

The most powerful secondary armament for a 35,000-ton battleship was projected for the *Richelieu* class—five triple turrets with 152-mm guns. More important was the

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The only Allied battlecruisers built during the World War II era were the French Dunkerque and Strasbourg and the American Alaska and Guam. The Dunkerque (top) was an exceptionally powerful ship for her displacement (the Strasbourg even more so because of improved protection). The French ships mounted eight 330-mm guns in quadruple turrets on a full-load displacement of 34,872 tons. The ships also had heavy armor protection and a very formidable torpedo defense system for their displacement. The Alaska, shown below, and her sister ship Guam mounted nine 305-mm guns in three triple turrets with no torpedo defense system and much lighter armor protection. The American ships featured a more sophisticated electronics suite and improved accommodations. In a conventional gunnery engagement, the American ships would have been overwhelmed by the more heavily armed and better protected French battlecruisers.

fact that they were to be of a dual-purpose type, since French naval constructors believed that only such guns should constitute the secondary armament of a capital ship. These were designed for barrage antiaircraft fire, which proved to be of limited effectiveness during World War II. The actual in-service maximum elevation of the triple mounting could not match the design objective, and the guns could not be loaded beyond 75 degrees. These limitations reduced their value as high-angle antiaircraft guns and, combined with their delayed production and slow rate of fire, forced the ultimate inclusion of 100-mm guns in the antiaircraft battery at the expense of two 152-mm triple turrets. The most powerful secondary and light antiaircraft battery for a modern battleship evolved from this combination of 152-mm and 100-mm guns when the *Jean Bart* was reconstructed after World War II. It was decided not to repeat using the 40-mm Bofors as the close-in defense as in the *Richelieu*, but to use instead a new model 57-mm Bofors. The antiaircraft battery was radar controlled, making it more effective.

Armor and underwater protection had been important considerations in the design of the *Richelieu* class. The main side belt was inclined and the side armor thickness reduced in an attempt to reduce the armor weight. Inclining the belt saved some weight and permitted venting the underwater explosion outside the armored citadel. Although these ships had good armor protection, they also had the deepest torpedo protection of any battleship built. With the system predicated on a 300-kilogram charge, the breadth of the system was 7 meters in the *Richelieu* at the widest point along the citadel. An additional compartment behind the torpedo bulkhead for a cable passage added another 1.2 meters. A serious overload condition in these ships resulted in a change to the *Jean Bart*'s underwater hull form by the inclusion of bulges. As a result, the depth of the torpedo protection, not including the cable passage, was increased by 1.27 meters to a total of 8.27 meters. This bulging also increased the effectiveness of the torpedo-defense system so that it could withstand 500-kg charges.

As in all capital ships, the *Richelieu* class had an "Achilles heel," the secondary armament protection. This was exposed during the shelling of the *Jean Bart* by the USS *Massachusetts* at Casablanca. The secondary magazines were vulnerable to large-caliber projectiles, since the deck armor protection was less than that provided over the main-battery magazines. This weakness would have been rectified in the *Gascogne*, however, where the main and secondary magazines would have been provided equal deck protection.

The two completed *Richelieu*-class ships were the fastest "35,000-ton" battleships. To attain a 30-knot speed, the French naval constructors provided a compact, yet powerful, propulsion plant that produced almost 178,000 metric horsepower with a relatively light weight of 13.7 kg/mhp. This had been reduced from the type of propulsion plant used in the *Dunkerque*, which was 14.65 kg/mhp. The propulsion plant featured the Sural-Indret (Norguet) boiler, which was supercharged and highly compact, with a pressurized furnace. The boiler required a higher grade of fuel oil than was normally used in steam plants of that period and had a slightly higher fuel rate than a comparable Indret nonsupercharged boiler, which are reasons why it never was used in later French warships.

The *Richelieu* and *Jean Bart* had good endurance, but less than that sought in the original design requirements and less than that of the American *North Carolina*, *South Dakota*, and *Iowa*-class battleships.

Of the four "35,000-ton" battleship classes completed (the *King George V*, *North Carolina*, *South Dakota*, and *Richelieu* classes), the French battleships rate as almost equals to the *South Dakota*, which had slightly superior armor protection and more range; however, when compared to the slightly larger German *Bismarck* and Italian *Vittorio Veneto* classes—ships that the French warships were to be matched against—

the *Richelieu*-class battleships were superior. They had better guns with more penetrative power, greater endurance, superior armor protection, and a much better underwater protection system.

Russia. During the early thirties, the Eighth Party Congress of the Soviet Union decided that Russia needed a powerful oceanic navy and that it was essential to create one in a short period of time. Russia was not bound by treaties to limitations in displacement or total fleet tonnage. Russian shipyards were only slowly being rebuilt, however, and related industries were just being set up. Therefore, due to the lack of experience in modern warship design and construction, discussions were held with various foreign governments, shipyards, and design offices. Although designs were delivered to Soviet authorities for several battleships, the Russians eventually pursued their own course of action. Nevertheless, such foreign assistance helped the Russians with their design work, since the technical background and insights gained from the foreign experts was helpful in the Russian design of modern battleships. Russia never achieved the industrialization originally projected, as available capacity would not permit normal domestic steel production, rearmament for the army, and battleship construction for the navy. Therefore, the Soviets eventually were forced to cancel their capital-ship construction projects.

The *Sovetskii Soyuz* was a Russian design with guns and propulsion machinery to be produced in the Soviet Union. It appears that this battleship class would have had a large beam, incorporating the Pugliese system of underwater protection, heavy armor protection, large horsepower with a maximum speed of some 29 knots, and a powerful gun armament. The large beam implies good stability characteristics, and with proper subdivision, these ships could have absorbed a considerable amount of battle damage. The only weak point might have been in the structural details of the Pugliese system, which the Russians probably copied directly from the Italians; this deficiency would have been centered in the riveted connection between the holding bulkhead and the bottom shell.

Details of the propulsion plant are not known, but the requirements apparently called for a maximum speed of 29 knots and an endurance of 7,200 miles at 15 knots. The latter was comparable to French, American, and German modern battleships, but was rather large for a country that did not have an ocean-going navy at the time.

The *Sovetskii Soyuz*-class battleships appear to have been an excellent design. They would have been equal to, or better than, the German H-39 design, but not as good as the Japanese *Yamato* or the American *Montana* classes. Their strongpoints were an excellent secondary and antiaircraft battery, the main armament, and the large beam with fairly deep underwater protection, which would have been definitely superior to the *Yamato* class.

The *Kronstadt*-class ships were officially termed "heavy cruisers" by the Soviet Navy, but they were in every sense battlecruisers. These ships were to be extremely fast, heavily armed, and well protected on a full-load displacement of some 38,360 metric tons. Whether all of these objectives were achieved is not known, for only limited fragmentary evidence is available on their final characteristics. This much is known:

- Main armament featured the 305 mm/56-caliber gun, which the Russians have claimed was the most powerful of its caliber ever built.
- Armor protection would have been better than average for a battlecruiser.
- Maximum speed was to be 33 knots.

Based upon these known details, it would appear that the *Kronstadt* class might have been an excellent modern battlecruiser design during the World War II era.

The Soviet Navy planned a third capital-ship class after World War II. The *Stalin-grad* class would have combined new technology with the lessons learned from the war. These ships would have been armed with the 305-mm/56-caliber gun and probably would have had a protection system equal to, or better than, that provided the *Kronstadt* class.

Netherlands. Twice during the battleship era the Netherlands planned to construct capital ships, and both times studies were begun close to the outbreaks of World Wars I and II. As a result, neither design was ever completed, nor were they resumed after the cessation of hostilities.

The increasing strength of the Japanese Navy and the political changes thought by Dutch authorities to be coming in the Pacific area forced the Netherlands to begin design studies of a capital ship in February 1939. Since the Netherlands lacked expertise in modern capital-ship design, it was necessary to enlist the assistance of foreign navies to help in the design and possibly provide some of the necessary armor, armament, and outfit.

The first approach was made to Germany during 1939, when the battlecruisers *Gneisenau* and *Scharnhorst* were being completed. The Germans were willing to provide technical assistance just as long as it would not interfere with their naval expansion program. However, they were not willing to divulge the details of their underwater protection systems. Discussions with the Italians during 1940 also proved negative, but they did offer the Dutch some advice on underwater protection systems. The design was in the final stages of completion when the Netherlands was invaded on 10 May 1940. All planning work ceased and was never resumed.

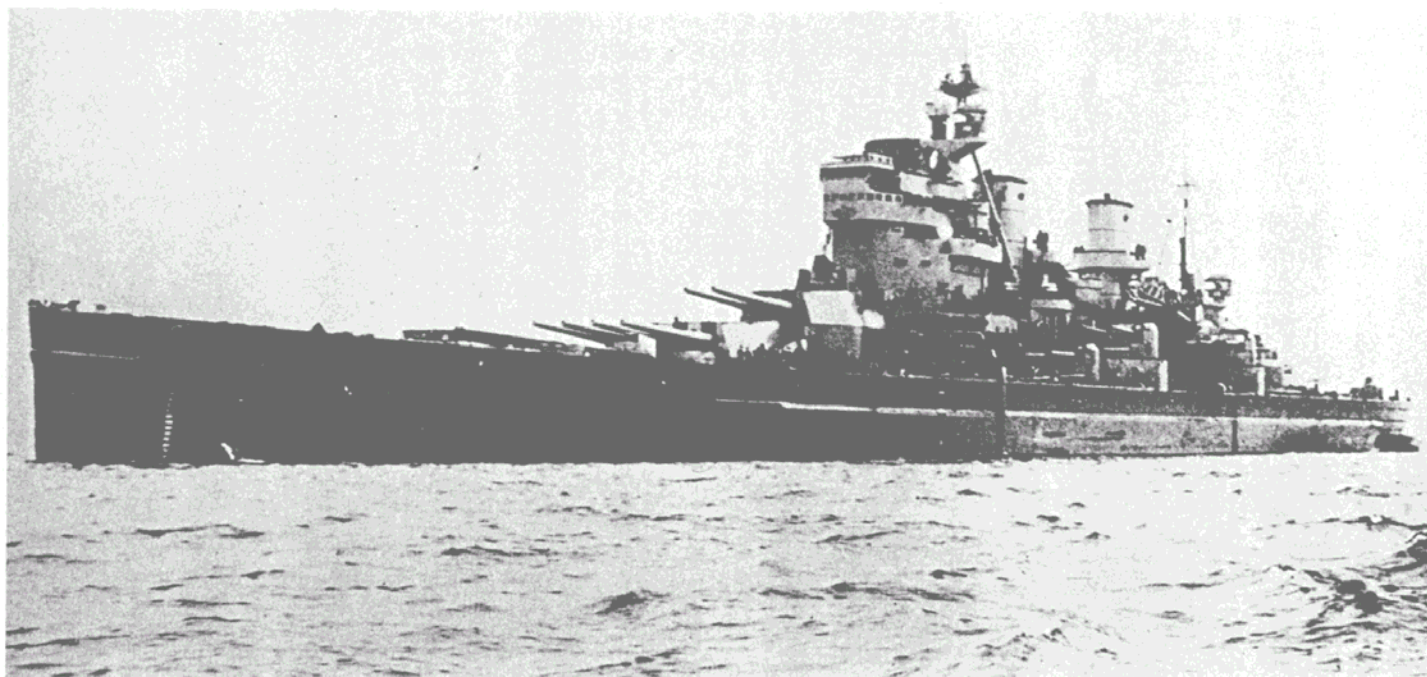
These vessels were an interesting design using the German 283-mm gun in three triple turrets. The ships were specifically designed for operations in Asiatic waters in opposition to Japanese heavy cruisers. The secondary armament was weak for Pacific operations and would have to have been modified substantially to be effective.

The armor protection was good for defense against 203-mm guns, but deck protection was inadequate for a modern capital ship. Details of the underwater defense system were still under discussion when the design work terminated.

The Dutch battlecruisers were designed to have a speed of 33 knots in tropical waters. Although they could outfight Japanese heavy cruisers, they would have been no match for any Japanese battleship.

United Kingdom. The United Kingdom, like the United States, observed a naval holiday for a decade to avoid the enormous costs of a major building program. There were some doubts about the future of battleships, and a debate raged between the air enthusiasts and the surface-ship proponents. By 1935, Germany, France, and Italy had committed themselves to the construction of 35,000-ton battleships, and this made it mandatory for the British government to reexamine its position on battleship construction. At the time, the British fleet was undergoing a modernization program with the addition of antiaircraft guns, additional protection, and a complete overhaul of the propulsion plants of the *Renown* and some ships of the *Queen Elizabeth* class. In November 1935, development work had begun on a new 14-inch gun (Mark VII) which Great Britain emphatically advocated as the best armament for a

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The superior engineering efficiency of the North Carolina-class battleships (top) as compared to the King George V was the source of considerable frustration within the Royal Navy and particularly to Admiral Sir John Tovey when the American battleship operated with the Home Fleet. Primarily because of the enormous advantages of the relatively light-weight, high temperature-pressure steam propulsion plant in the American ships, they were able to attain better endurance, superior armament, and superior protection on similar displacements. Both ships were designed to satisfy the displacement limitations of the 1936 London Naval Treaty.

35,000-ton battleship. It was decided to arm the new ships with twelve of these guns in quadruple turrets. The design and plan work were to be expedited so that two ships could be laid down in January 1937. However, the armor protection was the source of much discussion until the design was finally completed. This, in combination with mandatory changes in the torpedo-defense system, resulting from the Job-74 experiments, required "B" turret to be changed from a quadruple to a twin mounting in order to save weight, which considerably delayed the final completion of the first two ships to 1940. The decision to change the main armament from twelve to ten guns was indeed unfortunate, for it undermined the entire rationale for using a 14-inch gun. Winston Churchill was quite critical of these ships, citing the fact that the United States was proceeding with a 16-inch battleship design and that Germany, France, and Italy were building battleships armed with 15-inch guns.

The *King George V* battleships were, perhaps, the weakest of those completed during the World War II era. This resulted not only from design shortcomings, but also from a number of extraneous constraints. One of the most restrictive constraints was the docking requirement, which limited the beam of these ships to 103 feet. This, in combination with the propulsion plant requirements, compromised the effectiveness of the torpedo-defense system and prevented the adoption of a truly adequate arrangement from a vulnerability viewpoint.

A second damaging factor was the monetary policy Parliament followed regarding arms expenditures before World War II. For example, it was necessary for the Controller of the Navy to take money allotted to armor experiments and use it to improve the protection of the *Barham*. The Air Ministry was persuaded to contribute some funding for the Job-74 experiment.

Money was not the only item necessary to the construction of a battleship. In particular, skilled workmen and designers were absolutely essential. The extensive battleship building holiday and economic slump led to the closing of many shipyards, several of which had specialized in battleship construction, dispersing a highly trained work force of designers, engineers, and workers. The yard in which the lead ship, the *King George V*, was built, had been closed for many years and was reopened only a short time before this ship was ordered. With the first two ships delayed because of the armament change, construction took longer than expected, and when war began in 1939 these ships were urgently needed. They could not be thoroughly tested and inspected as had been the case during World War I and peacetime.

The *King George V*-class ships were armed with the 14-inch gun (Mark VII), the smallest size main-battery gun fitted to a World War II battleship. It was not a powerful weapon, as the tabulation in Table 10-1 shows.

The 14-inch gun used on the *Canada* was a World War I model, and that for the *North Carolina* was the projected main-battery caliber before the changeover to 16-inch. However, the new British gun was a lighter-weight model using the radial expansion method in its construction. Its design was based on a longer barrel life, thereby meaning that there was a reduced powder expenditure and lower muzzle velocity.

An outstanding feature of these ships was the secondary armament of 5.25-inch/50-caliber dual-purpose guns, which were fitted to mounts with excellent training and elevating rates. These guns could fire to a maximum range of 23,400 yards. They also served with distinction on British cruisers of the *Dido* class, and with the addition of fire-control radar, they became a very potent battery.

The armor protection provided the *King George V* was only a moderate success. The main side belt was vertical and an inch thicker outside the main-battery magazines than along the sides of the propulsion plant. Splinter protection was later added to reinforce the belt when tests of the new 14-inch gun indicated a need. The

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The two best capital ships of the 35,000-ton class are shown here. The French Richelieu (top) had superior speed, similar protection, but a much more concentrated armament. The Alabama, of the South Dakota class, had a more powerful armament, good protection, but a somewhat lesser maximum speed. These two types were among the best capital ships to be built, being much more formidable warships than many less efficient designs of much greater displacement.

TABLE 10-1

Comparison of Main-Battery Guns

<i>Gun</i>	<i>Battleship Class</i>	<i>Shell Weight (pounds)</i>	<i>Muzzle Velocity (feet per second)</i>
14-inch (Mark VII)	<i>King George V</i>	1,590 (721)	2,400 (732 m/s)
14-inch (Mark I)	<i>Canada</i>	1,586 (719)	2,510 (765 m/s)
14-inch*	<i>North Carolina</i>	1,500 (680)	2,700 (823 m/s)
15-inch	<i>Bismarck</i>	1,764 (800)	2,690 (820 m/s)
15-inch	<i>Richelieu</i>	1,958 (888)	2,690 (820 m/s)
15-inch	<i>Vittorio Veneto</i>	1,951 (885)	2,789 (850 m/s)

* Original armament for *North Carolina* Class

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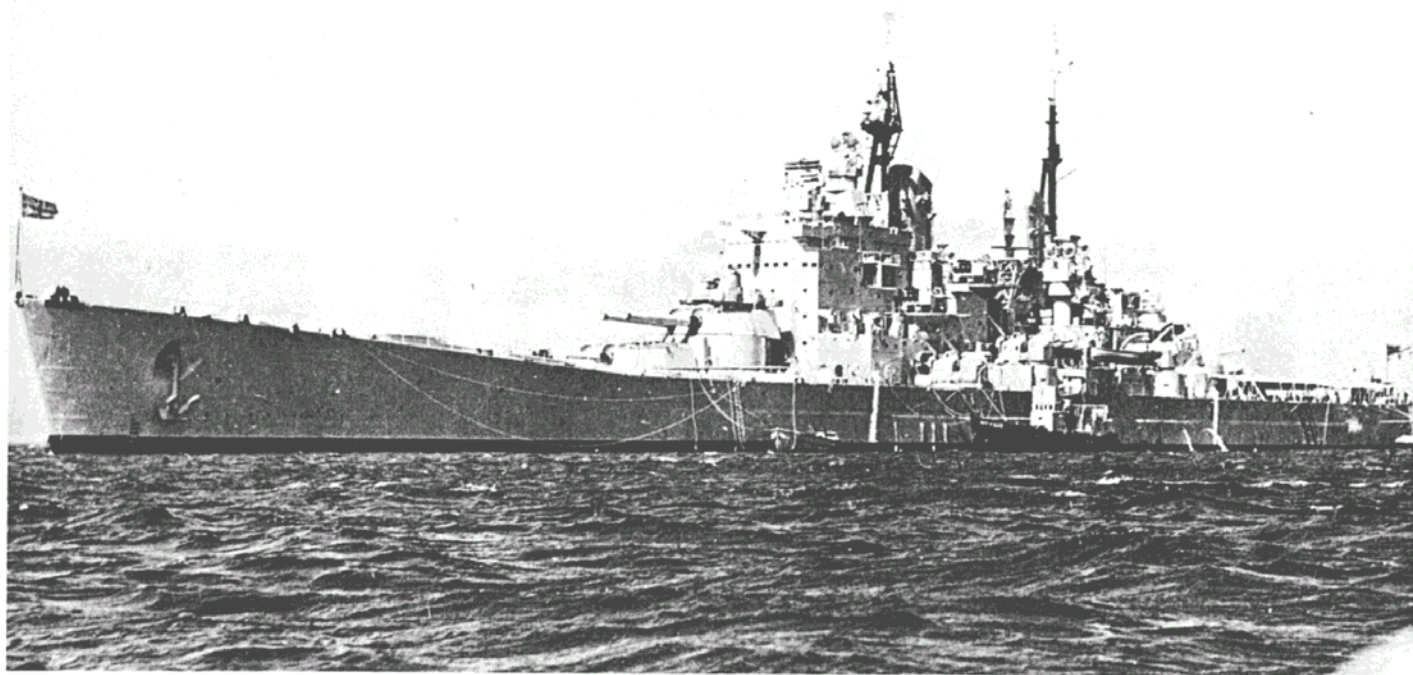
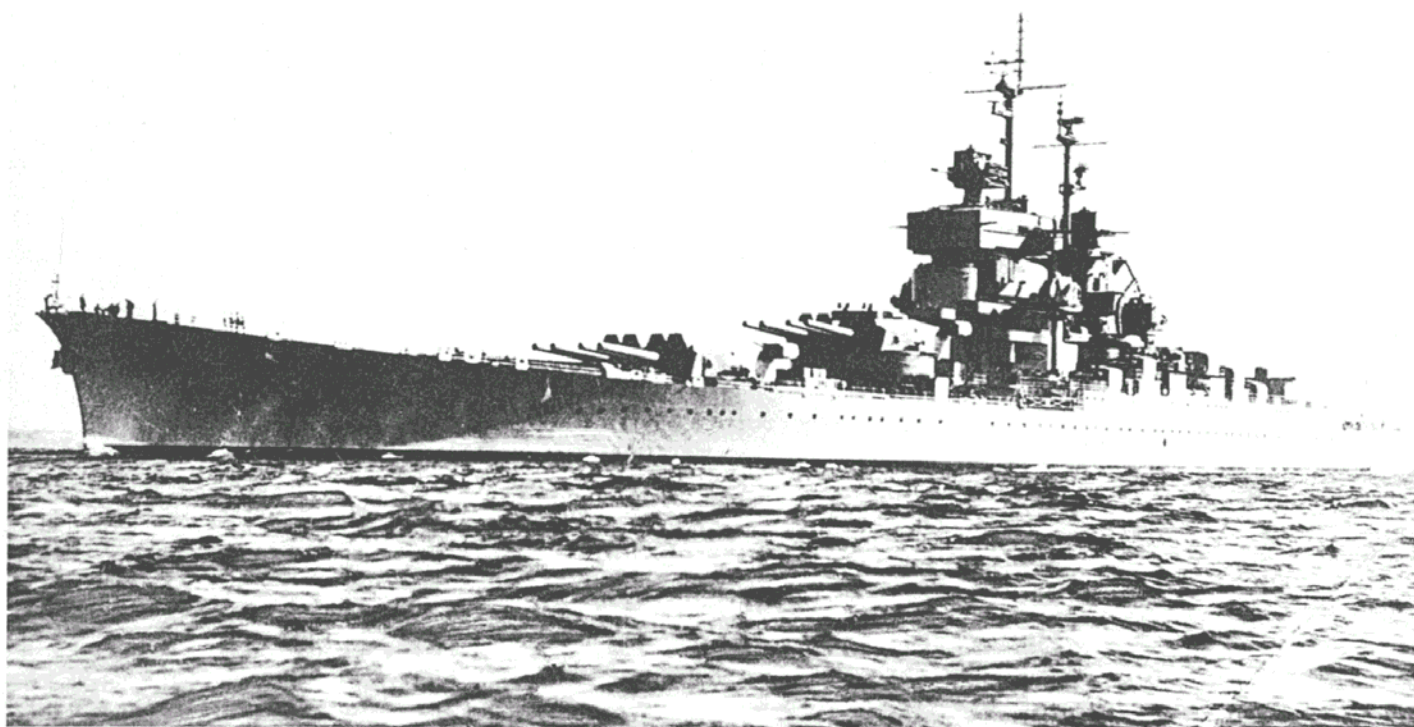
main deficiency of the armor protection, as demonstrated in the *Prince of Wales's* action with the *Bismarck*, resulting from the fact that the conning tower had only splinter protection, a policy that had been followed in the reconstruction of older battleships and battlecruisers. The devastation wrought in the main conning position by one 380-mm shell indicated that heavier protection should have been provided. A 203-mm shell hit in one of the 5.25-inch handling rooms demonstrated the risk of providing light protection for the secondary gun positions on this and other modern battleships.

Postwar firing trials indicated that the 14-inch and 15-inch side armor plates on the *King George V* were the equal of 17.5-inch to 18.75-inch American class-"A" armor. The loss of the *Prince of Wales* focused much attention on the design of these ships, since they represented the latest British thought on battleship construction, and particularly on the torpedo-defense system design, which had been derived through the Job 74 Experiment. The material lesson of the loss was that the principle of the sandwich system of side underwater protection was sound, but that its structural details were poor and could have been modified only in new construction. Basic to this improvement was the lifting of dockyard limitations and displacement restrictions that limited beams to 103 feet. Also, analysis showed that the riveting of structure in the system and its structural arrangement prevented the proper elastic and plastic deformation from occurring and that welding, if it had been perfected, would have been a better alternative. One of the greatest defects in the system was the imperfection of structural detail design that permitted notches and struts to exist that prevented the system from properly absorbing the energy of an underwater explosion. Ideally, the space on the inboard side of the protective bulkhead should not flood or sustain any leakage; however, some leakage had to be accepted in riveted construction due to the straining of riveted joints, and where pipes pass through structure, there will always be some weakness.

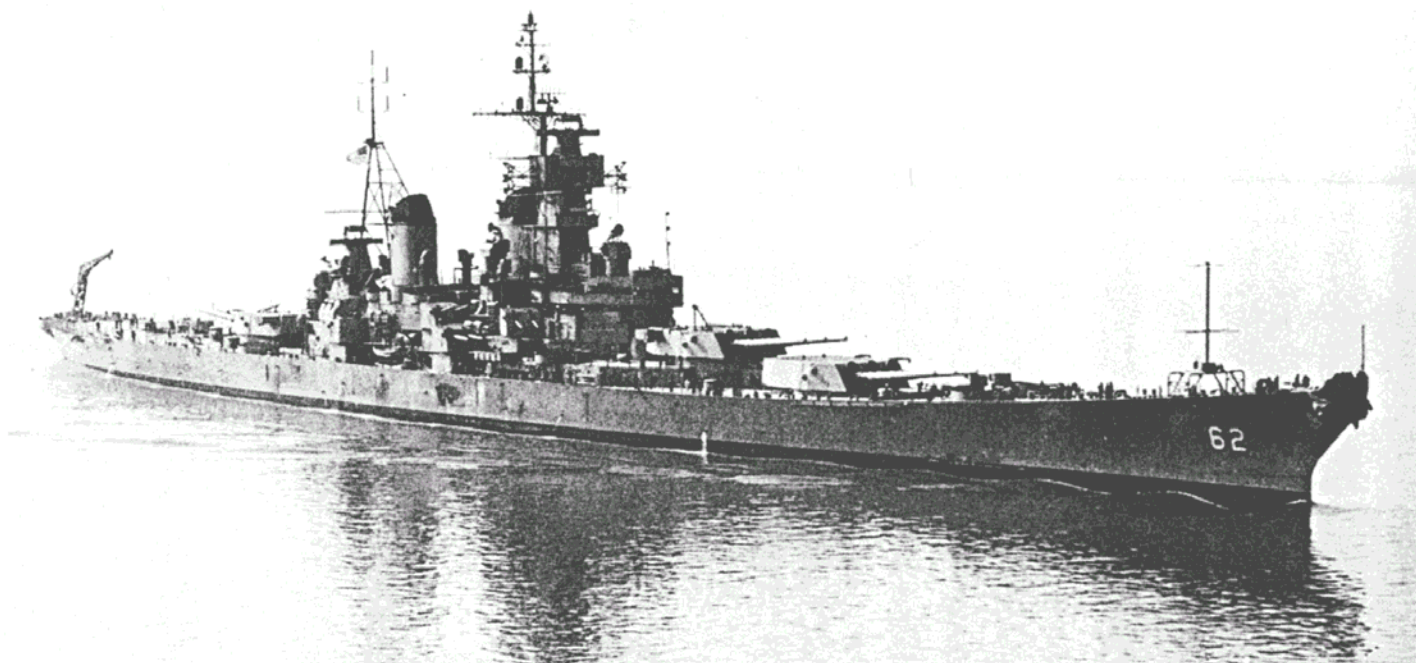
The major problem with the torpedo-defense system in these ships was its failure to contain an explosive charge much less than that used in experiments to confirm its designed resistance. The loss of the *Prince of Wales* provided many lessons in the design of a sandwich-type underwater defense system:

- The space above the system should be part of the system.
- Longitudinal divisional bulkheads within the system should extend one deck above the protective layer to lessen the likelihood of stress concentrations and progressive flooding after an underwater detonation.
- The deck above the system should be reinforced, with only a limited number of penetrations.
- Major transverse bulkheads in way of the holding bulkhead should be so designed that deformation will not be carried inboard.

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The last generations of battleships of the French, Royal, and United States Navies are shown here. The Jean Bart (top), due to exigencies of war, was not finally completed until 1952. The Vanguard (bottom) was completed in 1946 with a main battery of obsolete 15-inch/42-caliber guns of World War I vintage, taken from spares in an effort to accelerate her construction. The Iowa, New Jersey, Missouri, and Wisconsin were the finest battleships ever built, with an unmatched combination of offensive power, protection, sophisticated electronics, and high speed provided by an exceptionally efficient propulsion plant.



The USS New Jersey is shown here in March 1968 shortly before her recommissioning for Vietnam service.

There was nothing particularly novel about the propulsion plant of the *King George V*, although steam conditions were appreciably higher than those used in the *Nelson* and *Rodney*. The most noteworthy aspect of the propulsion plant was its lack of endurance, which forced a lower cruising speed and range than in most modern battleships; the range was only half that requested by the naval staff in the original ship characteristics. The fuel rate, tons per shaft horsepower hour, which is a measure of fuel efficiency, was high; many auxiliaries were steam powered. Endurance was later improved in the *Anson* and *Duke of York* with the addition of more fuel-oil capacity. The basic weakness of an inefficient propulsion plant remained unaltered.

One of the bitter lessons learned from the *Prince of Wales* tragedy was that the direct-current electric plant did not perform to expectations. The severe underwater damage ruptured the after ring main and flooded some of the compartments containing the generators. This led to the total disablement of machinery, ventilation, pumping, and gunnery in the stern of the ship, making it impossible to steer the ship, defend her, or pump out the flooding water. Since the electric demands were lower than in many of the modern battleships, the electric plant itself was rather modest in size for a World War II battleship. The prime source of power for the main guns was a hydraulic system, and galleys and pantries were equipped with oil-burning ranges.

Seakeeping qualities in capital ships were often neglected in design, and displacement limitations fostered many design compromises. In the case of the *King George V* class, there was an arbitrary limitation on bow freeboard to permit "A" turret to fire over the bow at a zero-angle elevation. This, in combination with the need to add radar, more antiaircraft guns, and the complement to man them, resulted in an even smaller bow freeboard than designed. As a result, the *King George V* and her sisters were very wet ships, with seas washing over their bows in even a fresh gale. This

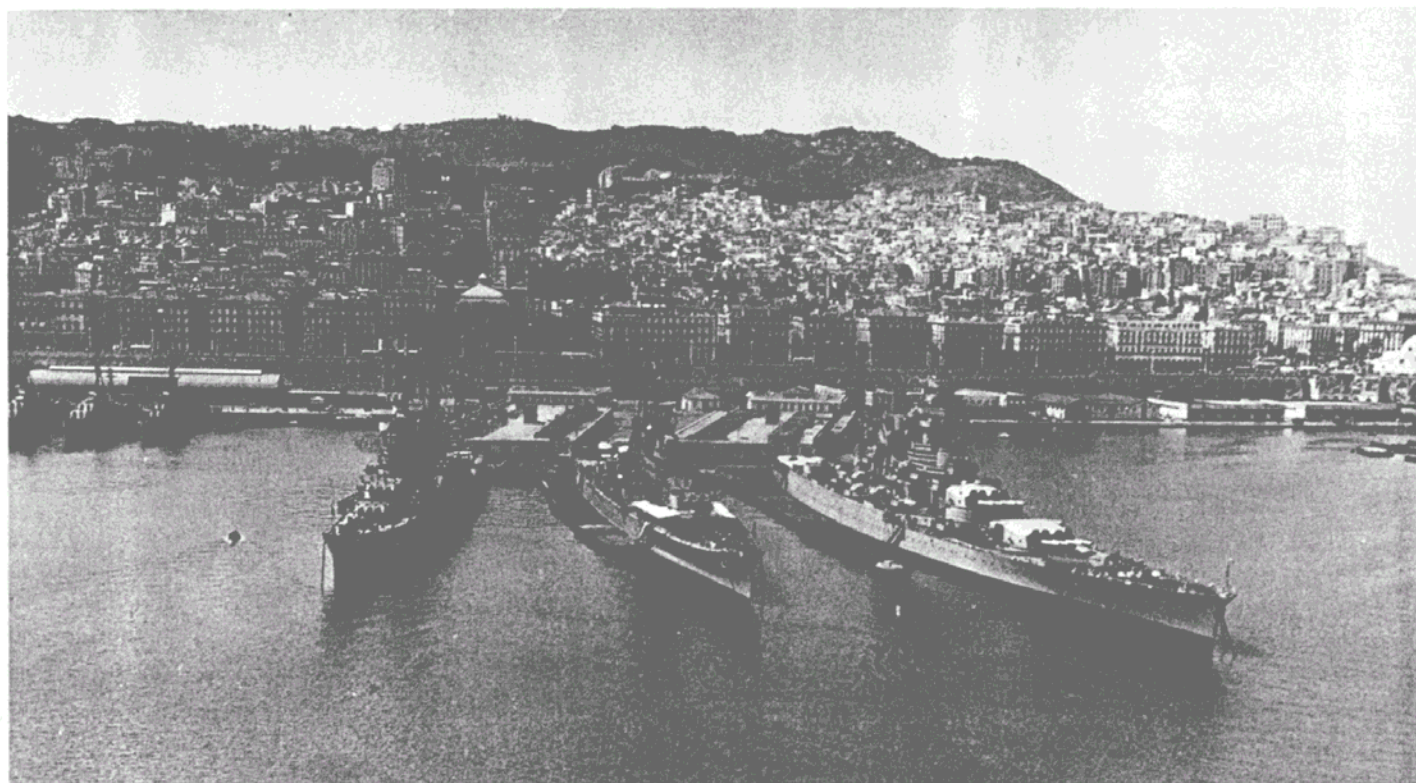
A comparison (Table 10-2) of the *King George V* and *North Carolina* is very instructive, as it covers two battleship designs that originated from the 1936 London Naval Treaty. The main armament was to be 14-inches and displacement was to be limited to 35,000 tons standard.

The weaknesses of the *King George V*-class design, many of them resulting from arbitrary restrictions, are readily apparent in the comparison. To satisfy the beam and draft restrictions and achieve the 35,000-ton displacement, the *King George V* ships had to be lengthened. Both ships were designed against 14-inch ordnance, yet the British steeply graded the protection in way of the main-battery magazines at the expense of protection in the propulsion plant. The *North Carolina* had thicker armor on her turrets, armor deck, and conning tower. Sloping the main side belt made it possible to achieve better protection with less weight. The machinery plants of the American ships, with double reduction gears and high pressure-high temperature steam, were more efficient in space, weight, and fuel consumption. In addition, they carried 2,000 to 3,000 tons more fuel. Therefore, there was a vast difference in the endurance of the two classes.

When Japan refused to sign the 1936 London Naval Treaty in 1937, it became possible to construct a 45,000-ton battleship armed with a 16-inch main battery. Great Britain commenced the *Lion*-class designs with the displacement restricted to 40,000 tons standard in the hope that other naval powers would follow. Again, an arbitrary restriction crippled another British battleship design. The basic arrangement

Comparison of North Carolina and King George V

	North Carolina 4 May 1937	King George V 3 April 1936
Standard displacement	35,000 (35,562)	35,490 (36,060)
Full-load displacement	42,330 (43,009)	40,530 (41,231)
Waterline length	714' (217.627)	740' (227.1)
Waterline beam	104' 3" (31.776)	103' (31.3)
Draft	31' 6" (10.973)	31' 6" (10.973)
Shaft horsepower	115,000 (116,595)	100,000 (101,387)
Maximum speed	27.5 knots	27.5 knots
Endurance	17,450 miles at 15 knots	14,000 miles at 10 knots
Armament	Twelve 14"/50 quadruple	10 14"/45 (2) quadruple (1) twin
	Twenty 5"/38 paired	16 5.25"/50 paired
	Sixteen 1.1" quadruple	32 2-pdr pom-poms quads.
Main side belt	12.0" sloped 15° (305)	14.71" (372)-vert.-mags 13.73" (348)-vert.-machy
Turret face plates	16.0" (406 mm)	12.75" (324)
Turret tops	7.8" (198 mm)	5.88" (149)
Barbettes	15.0" (381 mm)	12.75" (324)
Protective decks—magazines	6.3" (160 mm)	5.88" (149)
machinery	5.3" (135 mm)	4.90" (124)
Immunity zone versus USN 16"/45 fring 2,240-lb. AP shell	21,000-26,000 yards (19,205-23,778 m)	25,000-28,000 yards (22,360-25,603 m) (amidships) 23,000-31,000 yards (21,034-28,351 m) (main-battery magazines)



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The Richelieu is shown with units of the Sixth Fleet in the Mediterranean on 10 May 1952. The USS Newport News (CA 148) and a Baltimore-class cruiser are alongside.



The Vanguard during May 1947. Note the crew lining the railing and people ashore trying to view Great Britain's newest and last dreadnought.



This is a very famous photograph of the USS South Dakota in action during the Battle of Santa Cruz Island. During this engagement the American battleship shot down twenty-six planes with the aid of radar and the proximity-fuzed projectiles for the 5-inch guns. This action and other Pacific battles were important factors in the redesign of the Vanguard and Jean Bart.

of the *King George V* was retained, but the beam was increased, there was slightly more shaft horsepower, the main armament became 16-inches, and the armor protection was slightly improved. The commencement of World War II prevented the construction of these ships, although studies were made from 1940-42 to update the design to embody war experiences. With restrictions removed due to war, the displacement naturally grew.

The *Lion*-class design exhibited some of the weaknesses of the *King George V* class, namely:

- The underwater protection still had approximately the same dimensions and arrangement as the *King George Vs*.
- The electric plant still featured the ring main system.
- The endurance was no better than that of the *King George Vs*, despite a large displacement.
- Bow freeboard was essentially the same as the *King George Vs*.

Some of these weaknesses still existed after the 1942 redesign, so that the *Lion* class still remained a very close replica of the *King George V* class.

Soon after the outbreak of war, Sir Stanley Goodall realized that there would be considerable construction delays in the *Lion* class due to the development, production, and testing of a new 16-inch gun. There was also much competition for armor steel for both tank production and the *King George V* class. Therefore, he proposed that the eight 15-inch/42-caliber guns held in reserve for the battleships of the *Revenge* and *Queen Elizabeth* classes since 1925 be used for a new battleship design, which could be rushed to completion before the *Lion* class. This was the inception of the design of the HMS *Vanguard*.

War experience indicated that battleships had limited value, and construction was slowed. Although Prime Minister Winston Churchill was emphatic about completing the *Vanguard* as a battleship, work progressed very slowly after 1942; the ship was launched in 1944 and completed in 1946.

While the main armament featured an obsolete gun, the secondary armament of 5.25-inch/50-caliber guns and the power-operated radar-controlled sextuple 40-mm

Bofors battery provided a great volume of antiaircraft fire. Only a contemplated post-World War II rearmament of the four *Iowa*-class ships, which replaced the 20-mm and 40-mm machine-gun battery with 3-inch/50-caliber guns, and the reconstructed *Jean Bart* with improved antiaircraft defense, featured a better antiaircraft battery.

The armor protection, unfortunately, was not much different from that used in the *King George V* class. However, there was more splinter type protection. In general, the armor system was less than would have been expected for such a large ship.

The increase in beam in the *Vanguard* provided a slightly better underwater defense system than in the *King George V* class; the structural arrangement of the system was still similar.

The *Vanguard* had a slightly inferior propulsion plant when compared to other ships of her size, such as the *Bismarck* or the *Iowa*-class ships. This was due to conservative design principles and the lack of shore-based facilities to test a marine high temperature-high pressure power plant with double reduction gears.

The *Vanguard* exhibited very good seakeeping qualities. In joint NATO exercises in the Norwegian Sea in 1953, she easily rode the same seas in which the *Iowa* shipped a great amount of green water. This performance was attributed to the increase in bow freeboard and the elimination of the staff requirement concerning the zero-angle fire of "A" turret. Three breakwaters were added, and the anchors were recessed to help disperse the seas and eliminate spray formation.

Few of the battleships discussed in this volume saw active service after World War II, except to "show the flag" or to be used for training. The rapid development of guided missiles and the advent of the nuclear age profoundly influenced warship design. The Royal Navy considered converting the *Vanguard* and *King George V*-class battleships to guided-missile capital ships, to provide more missile defense for their carrier task forces. These plans were never realized because of the large reconstruction costs and the fact that the propulsion plans and hulls would be twenty to twenty-five years old after conversion, requiring much maintenance to keep them operational. The last operational European battleship was the *Jean Bart*, which was extensively modified after World War II to carry a more efficient antiaircraft battery and more sophisticated radar equipment. The age of the battleship in Europe ended when she was scrapped in 1971.



APPENDIX A

Full-Scale Ordnance Trials

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In the decades following the end of World War I, the great naval powers conducted systematic full-scale ordnance trials in efforts to improve their understanding of the complex phenomena involved in the detonation of large explosive charges against the sides of ships, and the performance of armor systems in resisting shellfire.

These trials frequently involved former German capital ships, such as the American trials involving the *Ostfriesland* and the British tests involving the *Baden*. In some cases, former active-service capital ships of the navy conducting the tests were used, such as in the Royal Navy experiments with the *Monarch*, *Marlborough*, and *Emperor of India*. There were also trials on the incomplete hulks of new-construction warships, such as the U.S. Navy's trials on the *Washington* (BB-47) and the Japanese tests on the *Tosa*, both ships discarded under the terms of the Washington Treaty of 1922. A discussion of the *Tosa* experiment is in volume I, *Battleships, United States Battleships in World War II*.

United States

Tests on the USS Washington (BB-47). The *Washington* was a *Maryland*-class battleship that had been authorized in August 1916 and built by the New York Shipbuilding Corporation in Camden, New Jersey. Her keel was laid down on 30 June 1919 and the ship launched on 1 September 1921. During the Washington Disarmament Conference, it was decided to complete only three of the four ships authorized in this class and discard the *Washington*. Since the ship was 76 percent complete and represented the latest U.S. thought on battleship design, it was decided to expend her in weapons tests, which were to include bombs, shells, and torpedoes. The *Washington* was finally sunk on 25 November 1924 after being hit by fourteen 14-inch shells.

The characteristics of a *Maryland*-class battleship were as follows:

Displacement—Normal	32,980 tons (33,519 mt)
—Full Load	34,013 tons (34,569 mt)
Dimensions—Length on waterline	600.0 feet (182.88 m)
—Beam	96.0 feet (29.26 m)
—Draft (DWL)	30.36 feet (9.25 m)
—Depth	46.25 feet (14.10 m)
Armament—Main	eight 16"/45 (406 mm) guns in four twin turrets
—Secondary	twelve 5"/51-caliber (127 mm) guns (ten in casemates and two in open mounts)
—Antiaircraft	eight 3" (76 mm)
—Torpedoes	two 21" submerged tubes (533 mm)

Battered by fourteen 14-inch shell hits, the incomplete Washington (BB 47) founders on 25 November 1924. One of the many victims of the Washington Treaty, the Washington was almost 76 percent complete when work was stopped. The battleship New York is in the background.

Shaft horsepower	28,900 (Designed)—(29,300 mhp)
Speed	21 knots
Protection—Main side belt	13.5" (343 mm)
—Armor deck	3.5" (89 mm)

The underwater explosion experiments conducted on the *Washington* were made with torpedoes with 400-pound TNT warheads, and a 1,000-pound charge was placed against the ship's side about half draft. The first test with the 400-pound torpedo warhead produced a list of five degrees. The second test was made with a similar torpedo, but at a deeper setting. The damage to the ship was greater than expected and was attributed to the fact that the explosion occurred near the turn of the bilge. There were minor leaks in the torpedo bulkhead, which eventually caused progressive flooding of inboard spaces. The list of the ship was only two degrees. The test with the 1,000-pound explosive produced a list of three to five degrees.

The conclusions regarding these tests were:

- The five-compartment torpedo protection system of the *Maryland*-class battleships was considered satisfactory.
- An underwater explosion that occurs near the bottom of bulkheads in a torpedo-defense system, even if it be a five-bulkhead type, will produce some flooding inboard of the torpedo bulkhead, which, incidentally, was riveted.
- Should future developments result in the carrying of fuel or water against the shell, that it be done without the expectation of compromising the safety of the ship or her equipment.
- Air spaces against the shell were desirable.
- A torpedo hit on a "modern" battleship with regulation counterflooding measures will produce a list of five degrees.

The assumption concerning the air spaces was not of any value since it was not based on the tests, but on a source which was not referenced. The test results also did not give any basis for the conclusions reached regarding the fuel and water arrangement. In general, these tests did confirm that the torpedo protection system used in the *Maryland*-class battleships was satisfactory, but not enough data was generated to reach firm conclusions regarding a liquid or air backing in the outboard compartment of the system. There were indications that added protection should be provided under the machinery spaces.

United Kingdom

Underwater explosion test on HMS Monarch. Under the terms of the Washington Treaty of 1922, the United Kingdom had to divest itself of a number of dreadnoughts. It was decided to use the old battleship *Monarch* as an experimental hulk to test the effect of a large noncontact underwater explosion on the hull of a battleship. The *Monarch*, which went into service in the Royal Navy in April 1912, had the following characteristics:

Displacement—Full Load	25,870 tons (26,292 mt)
Dimensions—Length on waterline	577.0 ft (175.87 m)
—Beam	88.5 ft (26.97 m)
—Draft—full load	28.75 ft (8.76 m)
Armament—Main	ten 13.5"/45 (343 mm)
—Secondary	sixteen 4.0"/50 (102 mm)
—Machine gun	four 3-pdr
—Torpedo tubes	two

Shaft horsepower	27,500 (27,881 mhp)
Speed	21 kts.
Protection—main belt	12" (305 mm)

For the underwater test, the *Monarch* was fitted with a bulge, which was not integral with the ship's bottom. (See figures A-1 and A-2.) It was placed in way of her forward main-battery guns and only on the starboard side. An explosive charge of 2,084 pounds of TNT was placed approximately eight feet from the ship's side and below her bottom, midway between the two forward turrets. Sometime during August 1923 the experiment was finally carried out, and the *Monarch* was towed to Portsmouth for docking and examination of the damage sustained. On 20 January 1925 the *Monarch* was expended as a fleet target ship with aircraft attacking her during the morning, cruisers in the afternoon, and finally, battleships during the night. Despite heavy damage, the hulk was still afloat, but was finally sunk by the 15-inch guns of the battleship *Revenge*.

The general effect of the underwater explosion conducted during August 1923 appeared to have been a direct compressive action roughly concentric with the charge, and an upward impulsive action on the ship's bottom, probably due to reflection of the explosion from the bottom of the sea. The former crushed the bulge plating completely against the thick bulkhead, the latter being driven up the bottom between frames 44-74 to a maximum deflection of 2.17 feet at frame 62. The combined action caused the junction between the new and old structures to break along the brackets; in all cases, the tear took place through one line of rivets, the brackets remaining attached to new and old structure alternately.

The after lower corner of the bulge was torn away from the main hull plating and forced downwards approximately 4.5 feet below the keel line, so that the bulge structure rested on the stone bottom when the vessel was docked. It was concluded that

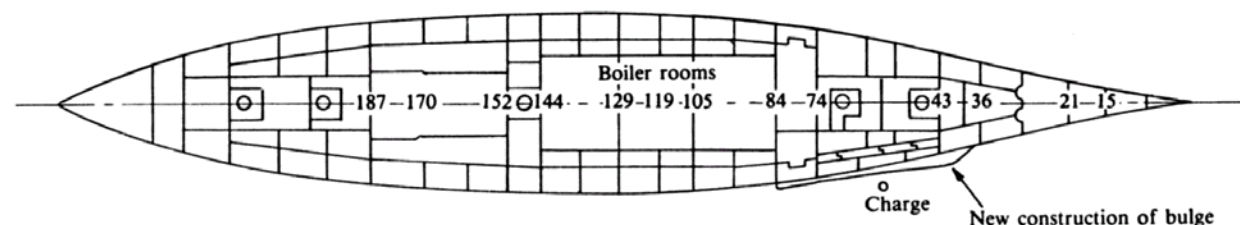


Figure A-1. Plan of Platform Deck—HMS Monarch

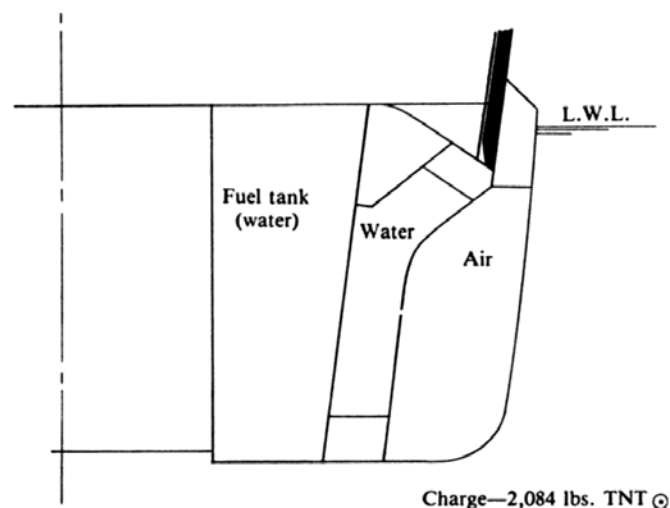


Figure A-2. Section of HMS Monarch

this parting in the bulge structure was due mainly to the small extent of new structure, causing marked discontinuity fairly close to the explosion's center.

The lower part of the torn structure was cut away in the drydock to prevent damage to the pontoon of the floating drydock. When the explosion occurred, it was observed that the vent plates on top of the bulge were blown skyward, and one of them, still flat, fell on the starboard side of the upper deck at frame 116. The vent plates at the bottom were blown off. The main thick bulkhead took a considerable deflection in a fair curve, but remained completely intact. The wood backing was not damaged. Brackets between the armor and torpedo bulkhead were in all cases torn away from the latter and remained connected to the former. The bilge keel was completely broken off along the line of welding, but the plating to which it was attached was not torn away at the connection. The side-armor joints near the explosion were strained; none of the bolts welded to the armor for connecting the top of the new structure to the ship's side were pulled out, but a few of them were broken off.

Inside the ship, the inner bottom was bulged up parallel with the outer bottom; the cover hatch leading from "A" shell room to "A" magazine was blown off; a watertight sliding door in the bulkhead between "A" and "B" magazines was badly damaged. The stanchions in the shell room were bent and broken at midspan. In some cases, the sole plates for the stanchions were pulled away from the platform deck, but in others, these plates were pushed through the deck. One stanchion in "B" shell room, which had been attached directly to the deck without any backup structure, was pushed through the platform deck without bending.

Paint peeled from the joints of armor on the crown and walls of the two forward turrets and barbettes. The leather bloomers had the bolts securing their segments broken over a 15-foot length. The flashtight aprons in the walking pipe spaces were intact, but became ineffective in the handling room because of the distortion in the magazine flats; the fittings themselves were not damaged. Flashtight doors on the central hoists in the magazine were intact, but in the shell rooms the doors were displaced and their fittings broken. The shell bins were wrecked. In the center engine room one condenser cover cracked, and water seeped through the fissure and flooded the engine room. The flooding was halted by closing the condenser inlet valve.

After the explosion, the *Monarch* heeled to starboard and trimmed by the bow. When the vessel was inspected at Portsmouth, she had the following drafts and list:

Draft forward	34.0 ft (10.37 m)
Draft aft	27.67 ft (8.44 m)
Mean draft	30.83 ft (9.41 m)
List (to starboard)	10.25 degrees
Increase in displacement	2,700 tons (2,744 mt)
Change in trim by the bow	11.42 ft (3.48 m)

Shell trials on SMS Baden. The German battleship *Baden* was used in firing trials in February and August 1921 to determine the effectiveness of British armor-piercing shells. These tests were to be referred to by British designers when evaluating the protective aspects of future battleships. The *Baden* was one of four battleships projected for completion by 1917, but the onset of World War I saw only two of these ships completed, although not in time for the Battle of Jutland. The characteristics of these ships were:

Displacement	28,148 tons (28,600 mt) Standard
	31,691 tons (32,200 mt) Full load
Length overall	590.55 ft (180 m)
Waterline length	588.58 ft (179.4 m)
Beam	98.42 ft (30.0 m)

Mean draft	30.54 ft (9.31 m) at full load
Armament	eight 15"/45 (380 mm) paired sixteen 5.9"/45 (150 mm) single two 3.46"/45 (88 mm) single 5 torpedo tubes 23.62" (600 mm)
Belt armor	13.78" (350 mm)
Deck armor	2.36"-3.94" (60-100 mm)
Shaft horsepower	55,505 (56,275 mhp)
Maximum speed	22.0 kts

The first trial was conducted on 2 February 1921, using the 15-inch guns on the monitor *Terror*. The range selected was 16,000 yards, which British naval constructors thought would be the future battle distance between opposing capital ships. As there was no guarantee that the *Terror* could hit the *Baden* consistently from this range, the distance between the two ships was reduced to 500 yards. To simulate the 16,000-yard range, the *Baden* was inclined 13.5 degrees towards the *Terror*, and the projectiles' charges were reduced. A series of 15-inch projectiles were fired to compare their performance and assess the extent of damage. The following description is the survey of damage done to the German battleship:

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Round	Shell	Filling	Target	Result
1	CPC	Powder	4" roof "B" turret	Burst on impact. Hole 6' 9" × 1' 11" in roof.
2	CPC	60/40 Shellite	4" roof "X" turret	Burst 20' from impact. Roof bulged 7" and cracked.
3	CPC	60/40 Shellite	7" battery armour	Struck casemate roof. Hole 12' × 3' and burst.
4	APC	70/30 Shellite	7" fore belt	Pierced and burst 38' from impact.
5	APC	70/30 Shellite	4" roof "X" turret	Burst 15' from impact. Roof bulged 2½".
6	SAPC	70/30 Shellite	4" roof "B" turret	Burst on impact. Roof bulged 1" and cracked.
7	CPC	Powder	7" battery armour	Struck casemate roof. Hole 6' × 3', burst 22' from impact.
8	APC	70/30 Shellite	10" upper belt	Struck plate edge and burst 7' from impact.
9	APC	70/30 Shellite	14" "X" barbette	Burst ⅔ way through plate. 17" diameter hole.
10	CPC	Powder	14" "B" barbette	Burst on impact. 1½"-deep mark on plate.
11	SAPC	70/30 Shellite	7" battery armour	28° to normal. Pierced and burst 20' from impact.
12	Light APC (1,520 lb.)	70/30 Shellite	7" fore belt	27° to normal. Pierced and burst 30' from impact.
13	APC	70/30 Shellite	4" roof "X" turret	Burst 15' from impact. Roof bulged 4" and cracked.
14	APC	70/30 Shellite	14" face "B" turret	Blind. Shell pierced. 18" diameter hole.
15	APC	70/30 Shellite	14" conning tower	30° to normal. Burst on impact. 4" deep bulge in plate.
16	APC	70/30 Shellite	7" battery armour	Pierced and burst 53' from impact.
17	APC	70/30 Shellite	10" upper belt	Pierced and burst 38' from impact, putting 2 boilers out of action.

On 3 February salvage work had to be discontinued due to a heavy swell, and much water was shipped through upper deck damage from Round 8 and through 5.9" gun ports rolling under water. The *Baden* eventually settled on the bottom with a 10° list. She was salvaged and docked three months later.

Second trials, 10 August 1921—Ship on even keel. Firing ship *Erebus*. Right 15" gun used, special charges to give striking velocity of 1,380 fps equivalent to 21,800 yards, except Round 9 as first trials.

Round	Shell	Filling	Target	Result
1	SAPC	70/30 Shellite	Forecastle deck over 7" battery armour	Ran along deck for 20' and burst 53' from impact. Little effect.
2	APC	70/30 Shellite	Unarmoured side forward	Burst 7' from impact. Considerable local damage.
3	APC	70/30 Shellite	7" battery and "A" barbette	Pierced battery, started disc in 7" barbette (54° to normal). Burst 6' from barbette.
4	SAPC	70/30 Shellite	Unarmoured side aft	Burst 52' from impact. Much damage.
5	SAPC	70/30 Shellite	7" battery and "B" barbette	Pierced battery and broke up 7' from impact.
6	APC	70/30 Shellite	Joint of "A" 14" barbette armour	Burst on impact (32° to normal). One plate displaced 3" maximum.
7	Target	Special	Upper deck aft	Burst 14' from impact. Local damage.
8	SAPC	70/30 Shellite	7" battery and "B" barbette	Pierced battery, large hole in 7" barbette (42° to normal). Broke up 28' from impact.
9	Target	Special	After CT. 6¾"	Burst on impact. Blew top off tower and other damage.
10	CPC	70/30 Shellite	Unarmoured side aft	Burst 10' from impact. Very great effect.
11	APC	70/30 Shellite	Superstructure above fc. deck	Blind. Passed through ship.
12	SAPC	70/30 Shellite	Superstructure above boat deck	Burst 10' from impact on hitting CT base (56° to normal.) CT undamaged, but considerable local effect.
13	CPC	70/30 Shellite	Superstructure above fc. deck	Burst 27' from impact. Considerable effect.
14	APC	70/30 Shellite	7" battery and "X" barbette	Pierced battery, started disc in 7" barbette (63° to normal). Shell blind.

The target shells had mainly TNT fillings, and were too destructive to use against *Agamemnon* (W/T controlled target ship).

11 August 1921—Four 520-lb. light case bombs (340-lb. charge) and one 550-lb. heavy case (180-lb. charge) exploded at rest.

One 520-lb. on roof "Y" turret.

One 520-lb. on SL platform.

One 520-lb. on forecastle deck near "X"—6' × 18" split in 1.2" deck and bulged down 3' over 16' diameter; 0.3" upper deck not holed.

One 520-lb. on upper deck near "Y"—hole 10' × 8' in 1.2" deck; main deck slightly dished.

One 550-lb. on boat deck near "B"—hole 22' × 21' in 0.3" boat deck; hole 12' × 8' in 1.2" upper deck.

15 August 1921—One 1,800-lb. bomb (900-lb. charge) exploded at rest. On boat deck near fore funnel, hole 12' × 20' in 0.3" deck; 1.2" deck below slightly bulged.

16 August 1921—*Baden* sunk by opening sea-cocks in 49°50'20" N, 2°21'20" W.

The important conclusion derived from these tests was that an outfit of 100 per cent armor-piercing shells should be able to defeat an opposing capital ship. Moreover, the damage sustained by the *Baden* and the performance of her armor protection were invaluable lessons in the design of armor in future British battleships.

Experiments with HMS Emperor of India and Marlborough. The Director of Naval Construction was concerned with the protection of British battleships against shells with underwater trajectories hitting below the termination of side armor belts and causing serious internal damage. Some tests were conducted in the late twenties and early thirties with small caliber shells, and some investigations were conducted on the behavior of shells during their trajectories under water. In addition, the airplane was making rapid progress, and it appeared that during the life span of a battleship built in 1930, it was reasonable to assume that bombing attacks from high-flying aircraft were entirely possible. The postponement of battleship construction made possible by the London Naval Treaty of 1930 provided the Royal Navy with another opportunity to conduct full-scale experiments.

Under the terms of the London Treaty of 1930, the Royal Navy had to reduce its battleship strength to fifteen ships. To achieve this, it was decided to dispose of the four battleships of the *Iron Duke* class, among others. The *Iron Duke* was converted to a gunnery training ship, the *Benbow* was sold for scrap in January 1931, and the *Emperor of India* and *Marlborough* were to be used for tests before being scrapped. The characteristics of the *Iron Duke* were:

Displacement—standard	28,430 tons (28,887 mt)
—full load	35,160 tons (35,725 mt)
Dimensions—length	660 ft (201.2 m)
—beam	90.5 ft (27.6 m)
—draft (SWL)	28.42 ft (8.66 m)
Armament—main	eight 13.5"/45 (343 mm)
—secondary	twelve 6"/45 (152 mm)
—antiaircraft	four 3-pounders/two 3" (76 mm)
—torpedoes	four 21" (533 mm)
Shaft horsepower	85,000 (86,179 mhp)
Speed	29 kts
Protection—Main side belt	9" (229 mm)
deck	3" (max) (76 mm)

The *Emperor of India* was subjected to shell attack while the *Marlborough* was used as a target for bombs. The lessons learned were as follows:

Emperor of India Tests

1. A shell with an underwater trajectory (diving shell) was used during the shell tests to determine the amount of damage that could be inflicted on the ship's underwater defense system. It was determined that a torpedo defense system had to have an armored torpedo bulkhead to prevent splinters from entering magazines or machinery spaces.
2. The deck-armor systems of the *Iron Duke*-class battleships or other battleships so armored were insufficient to defeat projectiles fired at extreme ranges (i.e. 20,000 to 30,000 yards).
3. Provision should be made to vent shell explosions.
4. Secondary guns mounted in turret-like enclosures should have their below-deck compartments isolated so that the blast and fragments from a shell hit would not put neighboring gun positions out of action.

Marlborough Tests

1. Magazines must be protected against splinters and flash.
2. Special care should be taken to prevent cordite from being directly exposed to bomb or shell explosions.
3. If magazines are not protected against splinters or flash, then venting arrangements of sufficient strength should be provided.

It was concluded from these tests that armor protection was the only effective means of magazine protection and that all British battleships and battlecruisers with the exception of the *Nelson* and *Rodney* had to have their protection improved. Several ships were to be reconstructed, that of *Warspite* being the most extensive. This reconstruction and the tests described above had some influence on the early designs of the *King George V* class in so far as armor protection and its arrangement were concerned.

Job 74. Before the construction of the *King George V* battleships and the aircraft carrier *Ark Royal*, the Royal Navy conducted a series of tests on a representative section of a capital ship. These tests were called "Job 74."

A number of small-scale trials had been conducted on underwater defense systems prior to the design of the *King George V* class. It was decided to conduct a full-scale experiment on a ship section, which became known as Job-74. Although the scantlings and general arrangement of the underwater protection system were similar to those adopted in the *King George V* battleships, they were not identical in all respects. For instance, the spacing of rivets in the test section had been increased over that used in the battleships.

In the Job-74 experiments, there were four main trials concerning underwater explosions. These were as follows:

(1) A 1,000-pound charge was placed against the ship's side at 15 feet below the waterline of the test section. In the test for the *King George V* this was 28 feet—the waterline at the standard displacement of 35,000 tons. Stiffeners on the torpedo bulkhead were placed inboard, and the bulkhead plating consisted of two 0.875-inch plates.

(2) A 1,000-pound charge was placed against the ship's side at 15 feet below the test section waterline. Stiffeners on the torpedo bulkhead were placed on the outboard side, half being welded and half being riveted. The bulkhead plating was a single-thickness 1.5-inch plate. The arrangement of internal structure was similar to that used in the aircraft carrier *Ark Royal*.

(3) A 250-pound bomb, containing 127.5 pounds of explosive, was placed in contact with the ship's bottom plating.

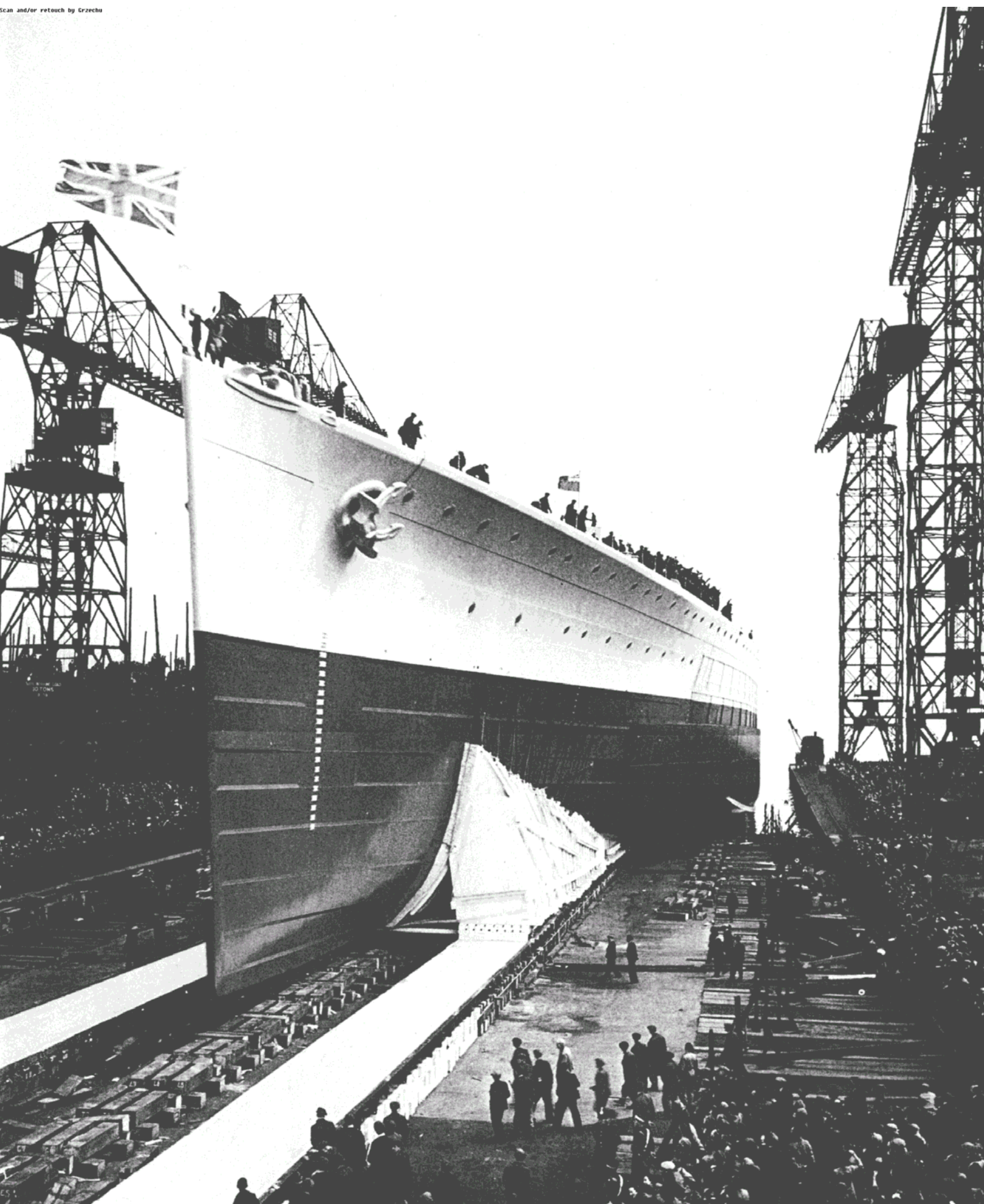
(4) A 440-pound torpedo warhead was placed five feet away from, but underneath, the ship's bottom.

Trial (1) was a direct tryout of the underwater protection system as per the May 1936 design. The trial was quite successful and confirmed calculations and expectations. It was concluded that this type of underwater defense system had proven successful in defeating a 1,000-pound charge in contact with the outer shell. It was also mentioned in the official report that since hull defense could not be made effective in resisting 1,000-pound charges, that a new design should be undertaken for a torpedo pistol. The method of securing transverse bulkheads in the test section was also found to require modification, which was accomplished in time for trial (2).

Trial (2) was a test of the underwater protection system contemplated for an aircraft carrier design, and it featured the extensive use of welding. As a result of this explosion experiment, the torpedo bulkhead failed over the portion that was welded,

but held over the riveted portion. However, due to the position of the riveted portion relative to the charge, it was considered doubtful whether the stresses in the two parts of the test section were equal.

Trial (3) was conducted to test the effect of a bomb exploding beneath a ship. Trial (4) represented a noncontact torpedo detonation. The lessons learned from both tests were that such an attack would cause flooding up to the armor deck between adjacent transverse bulkheads, unless the explosion occurred within 15 feet of such a bulkhead. Then the lower portion of the bulkhead could have been ruptured and the flooding extended into another main watertight compartment. It was also determined that heavy bottom framing should be avoided, because it spread the damage and caused more extensive flooding. Trial (3) indicated that modifications were necessary in the structural details of the bottom framing, and the alterations were incorporated in the test section modifications for experiment (4). These were found to be satisfactory.



APPENDIX B

The Prince of Wales

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In order to provide a better understanding of the internal arrangement of a battleship, an inboard profile and deck plans of the British battleship *Prince of Wales* are shown here, with a numerical and letter key to identify the locations of various compartments and spaces.

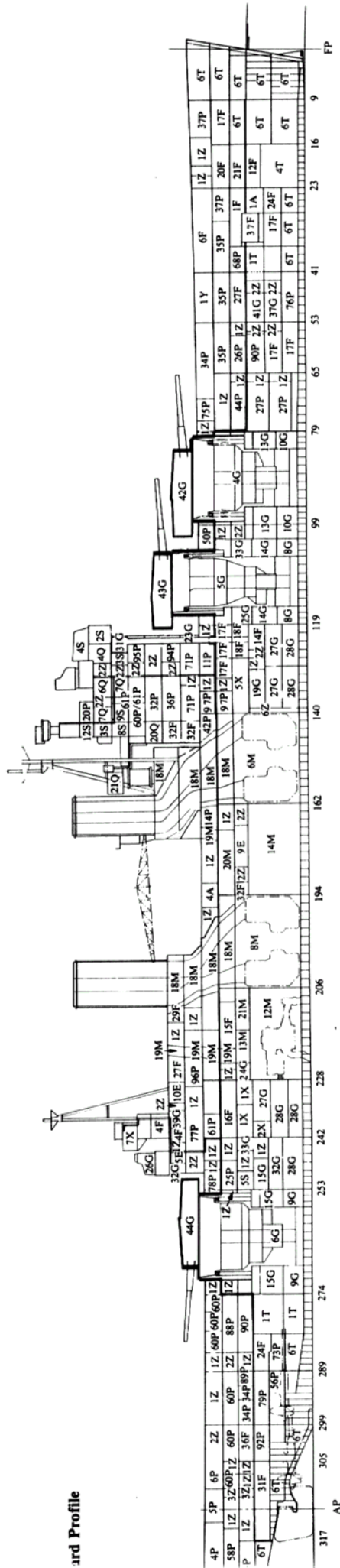
The key to the plans is categorized as follows:

- Aircraft (A)
- Damage Control (D)
- Electrical Plant (E)
- Outfit (F)
- Ordnance and Fire Control (G)
- Machinery (M)
- Personnel (P)
- Offices (Q)
- Ship Control (S)
- Tanks (T)
- Electronics (X)
- Minesweeping (Y)
- Miscellaneous (Z)

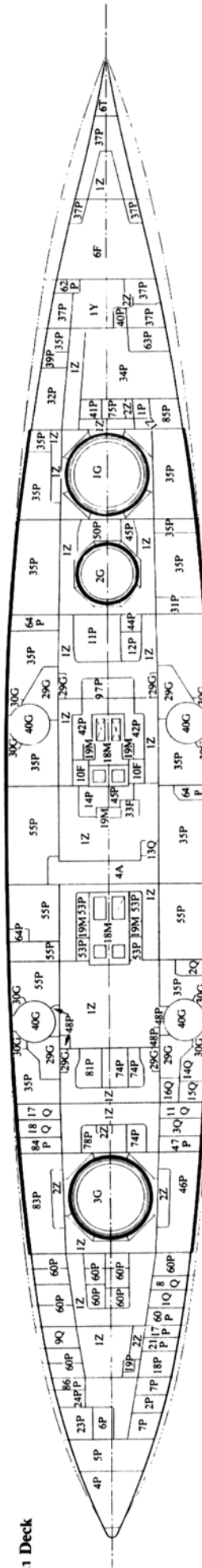
Many of the external features of the ship are also depicted on the outboard profile and overhead view, and some elements of the machinery are shown in the Machinery Schematic. Note that as the inboard profile depicts a centerline view of the ship, many of the port and starboard spaces are not keyed to the profile. Where possible, if there is a longitudinal bulkhead on the ship's centerline, the port compartment is shown on the inboard profile.

*The Prince of Wales at launch, 3 May 1939, at the Cammell Laird Shipyard, Birkenhead.
(Stewart Bale, Ltd.)*

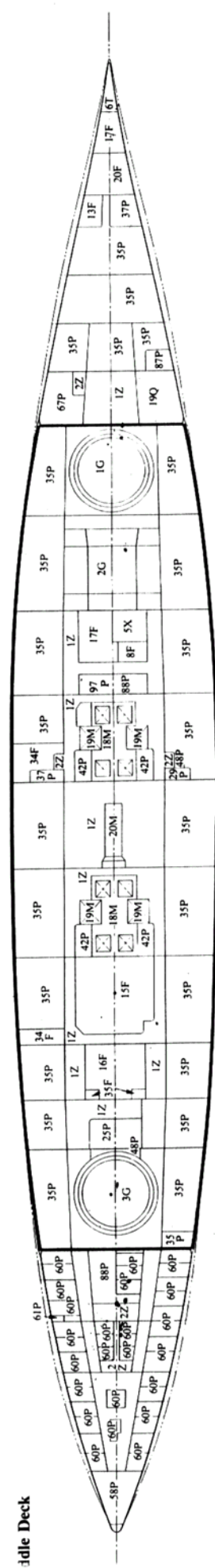
ard Profile



1 Deck



Idle Deck



Lower Deck

The diagram illustrates the Platform Deck of the USS Zumwalt (DDG 1000). It shows the ship's hull from a top-down perspective, with various deck areas, gun turrets, missile launchers, and other equipment labeled. The ship's name 'USS Zumwalt' is visible on the bow. The drawing is oriented vertically, with the bow at the top and the stern at the bottom.

[illegible]

KEY TO DRAWINGS OF TYPICAL BATTLESHIP (*Prince of Wales*)

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Aircraft (A)		8G "B" magazine	Personnel (P)
1A	Petrol control compartment	9G "Y" magazine	
2A	Bomb stowage	10G "A" magazine	
3A	Catapult	11G "A" turret space	
4A	Catapult mechanism space	12G "Y" shell handing room	
Damage Control (D)		13G "A" shell room	
1D	Damage control and telephone exchange	14G "B" shell room	
Electrical Plant (E)		15G "Y" shell room	
1E	Breaker room	16G "A" shell handing room	
2E	Diesel dynamo room	17G "B" turret space	
3E	Electrical lead passage and spare armature store	18G "B" shell handing room	
4E	Electrical store	19G 14-inch transmitting station	
5E	Junction box space	20G Magazine cooling-equipment room	
6E	Motor room	21G HA/LA calculating position	
7E	Power control room	22G Machine-gun magazine	
8E	Spare armature store	23G Communications tube	
9E	Switchboard room	24G Turret danger signals and air-conditioning machinery room	
10E	Electrical RU working space	25G Gunsight stores	
Outfit (F)		26G Main-battery rangefinders	
1F	Anchor-gear room	27G 5.25-inch shellroom	
2F	Antigas equipment store	28G 5.25-inch magazine	
3F	Awning room	29G Hoist compartment and RU store	
4F	Bosun's store	30G Spent cartridge space	
5F	Bower cable	31G Conning tower	
6F	Cable lockers	32G Pom-pom magazine	
7F	Boat-gear store	33G Sub-caliber machine-gun magazine	
8F	Cotton-waste stowage	34G Fireworks magazine	
9F	CO ₂ machinery compartment	35G Small-arms magazine	
10F	Crew cloakroom	36G Torpedo gunners and electrical stores	
11F	Enginesmith and copper-smith workshop	37G Gun spare gear store	
12F	Inflammable stores	38G Gunners instructional gear stowage	
13F	Lamp room	39G 5.25-inch casemate	
14F	Lower steering position	40G Gunnery stores	
15F	Machine shop	41G "A" mounting	
16F	Main naval store	42G "B" mounting	
17F	Naval store	43G "Y" mounting	
18F	L.P. room	Machinery (M)	
19F	L.P. and gyro room	1M "A" action machinery room	
20F	Paint room	2M "B" action machinery room	
21F	Paint store	3M "Y" action machinery room	
22F	Painted canvas room	4M "X" action machinery room	
23F	Palm compartment	5M "A" boiler room	
24F	Pump room	6M "B" boiler room	
25F	Sailmakers RU store and workshop	7M "X" boiler room	
26F	Silent cabinet	8M "Y" boiler room	
27F	Shipwrights' RU store	9M "A" engine room	
28F	Shipwrights' workshop	10M "B" engine room	
29F	Spare-motor engine stowage	11M "X" engine room	
30F	Spare parts store	12M "Y" engine room	
31F	Steering-gear compartment	13M Engineers RU store	
32F	Vent/fan room	14M Harbour machinery room	
33F	Photographic darkroom	15M Machinery store	
34F	Cloakroom	16M Shaft passage	
35F	Bollard hoist compartment	17M Thrust block recess	
Ordnance and Fire Control (G)		18M Uptakes	
1G	"A" barbette	19M Ventilators	
2G	"B" barbette	20M Engine room exhaust	
3G	"Y" barbette	21M Engineers shop	
4G	"A" handing room	22M Boiler stores	
5G	"B" handing room	23M Engineers' stores	
6G	"Y" handing room	24M Air-compressor room	
7G	"Y" turret space	25M Air-conditioning machinery	
		1P Ablution cabinet	
		2P Admiral's bath	
		3P Admiral's cabin	
		4P Admiral's day cabin	
		5P Admiral's dining	
		6P Admiral's pantry	
		7P Admiral's sleeping cabin	
		8P Admiral's store	
		9P Baggage store	
		10P Medical distribution station	
		11P Bakery	
		12P Bread-cooling room	
		13P Bulk clothing, soap, and tobacco store	
		14P Canteen	
		15P Canteen manager's cabin	
		16P Canteen store	
		17P Captain's bathroom	
		18P Captain's day cabin	
		19P Captain's pantry	
		20P Captain's sea cabin	
		21P Captain's sleeping cabin	
		22P Captain's store	
		23P Chief staff officer's day cabin	
		24P Chief staff officer's sleeping cabin	
		25P Church	
		26P Clothing issue room	
		27P Cold room	
		28P Cool room	
		29P CPO bathroom	
		30P CPO mess	
		31P CPO pantry	
		32P CPO reading room	
		33P Crew dressing room	
		34P Crew stateroom	
		35P Crew mess	
		36P Crew recreation space	
		37P Crew washroom and watercloset	
		38P Decontamination store (gas)	
		39P Dental surgery	
		40P Disinfector compartment	
		41P Dispensary	
		42P Drying room	
		43P Dry stores	
		44P Flour store	
		45P General mess store	
		46P Gun room (wardroom)	
		47P Gun room pantry	
		48P Hammock store	
		49P Implement store	
		50P Issue room	
		51P Linen locker	
		52P Main kitchen	
		53P Marines' greatcoats	
		54P Marines' living	
		55P Marines' mess	
		56P Marines' stores	
		57P Medical stores	
		58P Midshipmen's study	
		59P Music room	
		60P Officer's cabin	
		61P Officer's washroom and watercloset	
		62P Oilskin store	
		63P Operating room	
		64P Pantry	
		65P Petty officer living	

66P Petty officer washroom and
watercloset
67P Petty officers' reading room
68P Prison
69P Sanctuary
70P Senior officers' bathroom
71P Ship's galley
72P Sick bay
73P Spirit room
74P Subordinate officers'
dressing room
75P Surgeon's examination
room
76P Tropical clothing store
77P Wardroom
78P Wardroom officers'
bathroom
79P Wardroom stores
80P Wardroom wine store
81P Warrant officers' bathroom
82P Warrant officers' cabin
83P Warrant officers' mess
84P Warrant officers' pantry
85P Isolation ward
86P Chief of staff bathroom
87P Petty officer mess
88P Midshipmen's sleeping
space
89P Officers' bedding store
90P Provision room
91P Laundry
92P Gun-room stores
93P Warrant officers' stores
94P Potato store
95P Admiral's sea cabin
96P Wardroom pantry
97P Serving room

Offices (Q)

1Q Admiral's office
2Q Central store office
3Q Engineer's office
4Q Plotting office
5Q R.E.A. office
6Q Remote-control office
7Q Radio direction finder trans-
mitting office
8Q Secretary's workers office
9Q Staff office
10Q Stokers' office
11Q Torpedo office
12Q Type 284 office
13Q Marines' office
14Q Gunnery office
15Q Commander's office
16Q Annexe
17Q Captain's office
18Q Pay office
19Q School
20Q Meteorological office
21Q Transmitting office

Ship Control (S)

1S Admiral's chart house
2S Admiral's lookout
3S Chart house
4S Compass platform
5S Gyro room
6S Navigating store
7S Pilot house
8S Signal house
9S Signal shelter
10S Upper bridge

11S Chart and chronometer
room
12S Captain's chart house

Tanks (T)

1T Freshwater tank
2T Fuel oil
3T Hydraulic tank
4T Petrol store
5T Reserve feedwater
6T Watertight compartment
(void)

Electronics (X)

1X Central communications
office
2X Cypher office
3X Radar room
4X Radio direction finder
power room
5X Transmitter room
6X Central communications
office annexe
7X Wireless transmitter (radio)
office

Minesweeping (Y)

1Y Paravane stowage

Miscellaneous (Z)

1Z Passage
2Z Lobby
3Z Watertight trunk
4Z Air lock
5Z Void
6Z Air space



APPENDIX C

Battleship and Battlecruiser Guns

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Introduction. Battleships and battlecruisers in general have been perhaps the world's most popular warships, in terms of public interest in the ships, their characteristics, and their careers. As conventional capital ships served primarily as gun platforms, naturally their heavy guns were a major factor in their potential combat effectiveness. All other attributes were intended only to allow the ship to determine the time and place of the engagement, function effectively in combat, and withstand the destructive efforts of the enemy.

The primary weapons of battleships and battlecruisers, their guns, have been perhaps the subject of the greatest interest and speculation. Unfortunately, as is usually the case in such technical matters, one cannot merely assume that because one ship has 16-inch guns, it is necessarily more powerfully armed than another ship with 15-inch guns. Additionally, despite the potentially destructive effects of a given gun, as measured by ballistics and penetration performance, such capabilities are totally wasted if the gunfire control equipment is unable to accurately direct the gunfire.

In order to furnish a better insight into the gunnery capabilities of the capital ships described in this volume, and to compare the main-battery guns of these ships with contemporary foreign ships, this appendix is designed first to discuss in general various aspects pertinent to the question of the effectiveness of capital-ship guns in combat, and then provide added comments by way of explaining the detailed gun data tables that follow.

Main-battery guns. Capital-ship main-battery guns were primarily intended to engage and disable enemy surface ships, and particularly capital ships. For this purpose, the most important performance characteristic was the ability to penetrate the armor protecting the enemy ship. The armor-piercing shells fired by heavy naval guns relied exclusively on kinetic energy to force their way through the armor. The ability of a shell to penetrate armor is a function of a series of factors interrelated in a complex way not thoroughly understood even today. (The best formulations for estimating armor penetration are totally empirical as opposed to being derived from theoretical considerations.) The basic factors include the following:

- Diameter of the shell.
- Weight of the shell. The greater the specific frontal density—the weight per unit frontal cross-section area—the better.

Battleships were designed for one purpose—to serve as mobile floating platforms on which guns could be mounted. The 380-mm guns pictured here comprised the main battery of the Jean Bart. (Service Cinéma des Armées)

- Striking velocity. The greater the velocity, the greater the kinetic energy and the better the chances of penetration.
- Angle of fall. The more nearly perpendicular the angle of impact of the shell against the armor, the greater the thickness penetrated. If the angle is excessively oblique, the shell may ricochet from the armor.
- Characteristics of the armor. This is the most difficult factor to evaluate when comparing penetration tables for guns of different navies. Differing penetrations may be as much a function of varying qualities of armor as of the basic performance of the gun.
- Structural adequacy of the projectile. If the shell breaks up on striking the armor, or the fuse is rendered inert, then the projectile has been defeated by the armor, and the armor has accomplished its purpose. As a result, heavy-gun armor-piercing shells are massively constructed, with the explosive charge always comprising less than 3 percent of the total weight of the shell.
- Shape of the projectile. This affects the ballistic performance and the penetrative performance of the shell. Similarly, the adequacy of the cap, which is designed to lessen the tendency of the shell to ricochet, fundamentally influences the ability of the shell to penetrate armor.

The tendency in modern heavy naval guns was to accentuate penetrative performance by employing as heavy a shell as possible. This was a compromise judgment, partially sacrificing close-range performance in order to maximize the likelihood of penetration at longer ranges. The high-velocity light-weight shell (tank guns are classic examples of this approach to armor penetration) is outstanding at the closer ranges, but performance deteriorates severely as range is increased. This is a consequence of the fact that velocity is such a major factor in the kinetic energy of the projectile, and it deteriorates much more rapidly in the case of such relatively light-weight projectiles. The heavier shells, although with a lower muzzle velocity, were far superior in retaining velocity with range, hence were superior in armor penetration at longer ranges.

Capital-ship main-battery guns were also employed against lighter ships and shore targets, where some form of high-explosive shell is more suited to the target than the armor-piercing shell, which has a modest lethal radius—the distance in which any exposed personnel and unprotected equipment are subject to almost certain destruction by shell fragments. As a matter of fact, during the course of World War II, bombardment became so important to U.S. Navy capital ships that reduced charges were often used to reduce barrel wear. Barrel wear is a fundamental consideration in the performance of heavy guns. The bore erosion is so significant that the muzzle velocity and ballistic accuracy deteriorate with every round that is fired. The reduced velocity was of no particular concern with high-explosive shells—assuming the available ballistic range was adequate—as the striking energy is not a factor in the destructive effects of the projectile.

Secondary battery guns. The design concepts applied to capital-ship secondary batteries varied from navy to navy. In the navies of the United States, Great Britain, and the Netherlands, single-caliber dual-purpose batteries were selected. As indicated by the terminology, such DP guns were expected to be sufficiently heavy to be able to engage enemy light cruisers and destroyers successfully, while retaining sufficient flexibility and rates of fire to destroy enemy aircraft. All other nations that projected new capital ships—France, Spain, the Soviet Union, Germany, Japan, and Italy—opted for a mixed-caliber secondary battery.

The mixed-caliber secondary battery typically featured a light-cruiser gun of about 152-mm caliber, primarily designed to engage enemy surface ships (yet at times given a modest AA capability), while a lighter antiaircraft gun was used, varying from 100 mm to 127 mm in caliber. The major advantage of the dual-purpose battery was in its arrangement; more guns could be deployed, capable of engaging any one target, than would be available in the mixed battery with its single-purpose guns—each partial battery being less numerous than the total DP battery.

Antiaircraft projectiles are only as effective as their fuzes. Even under the best of circumstances, a direct hit on an aircraft was highly unlikely. As a result, the mechanical time fuze provided for a delay in detonation of the shell until it reached the predicted location of the aircraft. The inevitable time lag inherent in firing at ranges of several thousand yards made this prediction a chancy process at best. Hence, the Allied wartime development of the variable-time (proximity) fuze, which used a small radio transceiver inside the projectile to sense the proximity of the target and activate the fuze, was a major breakthrough in antiaircraft gunnery, considerably enhancing the effectiveness of heavy antiaircraft guns against air targets.

At times, the proximity or the mechanical time fuze might be used against surface targets, but normally the quick-acting point-detonating fuze was employed against "soft" targets. Projectiles with a delayed-action base-detonating fuze were used against armored or reinforced structures. The more protected location of the base-detonating fuze permitted its reliable operation—a time lag to permit the shell to penetrate the armor or heavy structure before detonation.

Machine guns. Antiaircraft machine guns, such as the 40 mm and the 20 mm, relied on high volumes of fire to contend with high-speed targets. Normally, such machine-gun projectiles had only a primitive contact fuze at best, and the smaller bore weapons, such as the 0.50 caliber, did not have explosive shells.

Gunfire-control systems. The great intangibles in evaluating gunnery systems are the relative capabilities of the gunfire control systems of the ships of the various navies. This is extremely difficult to quantify, and this study will limit itself to a few very superficial observations. In general, the Axis ships had somewhat of an advantage early in the war because of their superb optical rangefinding systems. Midway through the war, the Allies overcame this advantage with the development of radar gunfire-control systems. The Germans did have similar systems, but they did not approach the operational effectiveness of U.S. and Royal Navy systems.

Gun data table. Table C-1 is intended to give a detailed comparison of the relative characteristics of capital-ship main-battery guns. It is organized as follows:

- *Projectiles.* Types of shells and their weights.
- *Range table data.* Shell weight, muzzle velocity, and ranges. Wherever possible, new gun muzzle velocities are given. Frequently, range table calculations are based on an average estimated muzzle velocity over the life of the gun.
- *Armor penetration.* For a given shell weight, data for penetration of vertical and horizontal plates is given for specified ranges. To permit comparisons, wherever ballistic data permits, calculated penetrations using a detailed U.S. Navy empirical equation are given. This means such data may not be precisely correct, but it should give a very accurate measure of relative gun performance.

U.S. Navy, Royal Navy, and French Navy data is exclusively from official sources, while the information for the other guns is from a variety of official and unofficial but authoritative sources.

TABLE C-1
Capital Ship Main Battery Guns

Gun	Nation	Gun Weight		Shell Type	Weight		Muzzle Velocity	
		Kg	(lbs)		Kg	(lbs)	mm/sec	(ft/sec)
18.11" 460mm/45 (Type 94)	Japan	165,000	(363,762)	AP	1,460	(3,219)	780	(2,559)
16" 406mm/52 (SKC/34)	Germany	160,000	(352,740)	HE	1,360	(2,998)	805	(2,640)
16" 406mm/50 (Mark 7)	U.S.A.	121,615	(267,904)	AP	1,030	(2,272)	810	(2,657)
16" 406mm/45 (Mark 6)	U.S.A.	100,363	(221,220)	HE	1,030	(2,272)	810	(2,657)
16" 406mm/45 (Mark 2)	U.S.A.	100,363	(221,220)	AP	1,225	(2,700)	762	(2,600)
15" 381mm/50 (Model 1934)	U.K.	862	(1,900)	HE	862	(1,900)	820	(2,690)
15" 381mm/42 (Mark 1)	U.S.A.	1,225	(2,700)	AP	1,225	(2,700)	701	(2,300)
14.96" 380mm/52 (SKC/34)	U.K.	862	(1,900)	HE	862	(1,900)	803	(2,635)
14.96" 380mm/45 (Modele 1935)	U.K.	1,077	(2,375)	AP	1,077	(2,375)	732	(2,400)
14" 356mm/45 (Mark 7)	Italy	885	(1,951)	AP	885	(1,951)	850	(2,789)
12.99" 330mm/52 (Modele 1931)	Italy	824	(1,817)	COM	824	(1,817)	870	(2,854)
12" 305mm/50 (Mark 8)	U.K.	879	(1,938)	AP	879	(1,938)	732	(2,400)
11.14" 283mm/56 (KC/13)	Germany	879	(1,938)	HE	879	(1,938)	732	(2,400)
11.14" 283mm/54 (SKC/34)	Germany	800	(1,764)	AP	800	(1,764)	820	(2,690)
	France	800	(1,764)	HE	800	(1,764)	820	(2,690)
	France	884	(1,949)	AP	884	(1,949)	785	(2,575)
	France	884	(1,949)	HE	884	(1,949)	785	(2,575)
	U.K.	721	(1,590)	AP	721	(1,590)	732	(2,400)
	U.K.	721	(1,590)	HE	721	(1,590)	732	(2,400)
	France	560	(1,235)	AP	560	(1,235)	870	(2,854)
	France	522	(1,151)	HE	522	(1,151)	885	(2,904)
	U.S.A.	517	(1,140)	AP	517	(1,140)	762	(2,500)
	U.S.A.	426	(940)	HE	426	(940)	808	(2,650)
	Netherlands	330	(728)	AP	330	(728)	890	(2,920)
	Netherlands	315	(694)	HE	315	(694)	900	(2,953)
	Germany	330	(728)	AP	330	(728)	890	(2,920)
	Germany	315	(694)	HE	315	(694)	900	(2,953)

* Based on official data, no calculation possible.

Maximum Range			Armor Penetration (Calculated)					
m.	(yds)		mm/m	(in/yds)	mm/m	(in/yds)	mm/m	(in/yds)
41,400	(45,276)	Side	864 @ 0	(34.00 @ 0)	494 @ 20,000	(19.43 @ 21,872)	360 @ 30,000	(14.19 @ 32,808)
41,696	(45,600)	Deck	—		109 (4.30)		189 (7.43)	
43,000	(47,025)	Side	806 @ 0	(31.72 @ 0)	479 @ 18,288	(18.84 @ 20,000)	345 @ 27,432	(13.60 @ 30,000)
43,000	(47,025)	Deck	—		80 (3.15)		127 (4.99)	
38,720	(42,345)	Side	829 @ 0	(32.62)	509 @ 18,288	(20.04 @ 20,000)	380 @ 27,432	(14.97 @ 30,000)
38,059	(41,622)	Deck	—		99 (3.90)		169 (6.65)	
33,741	(36,900)	Side	755 @ 0	(29.74 @ 0)	448 @ 18,288	(17.62 @ 20,000)	324 @ 27,432	(12.77 @ 30,000)
36,741	(40,180)	Deck	—		109 (4.29)		194 (7.62)	
34,766	(38,200)	Side	737 @ 0	(29.03 @ 0)	389 @ 18,288	(15.3 @ 20,000)	292 @ 27,432	(11.5 @ 30,000)
		Deck	—		82 (3.24)		146 (5.73)	
44,899	(48,884)	Side	814 @ 0	(32.07 @ 0)	510 @ 18,000	(20.06 @ 19,685)	380 @ 28,000	(14.93 @ 30,621)
46,533	(50,899)	Deck	—		73 (2.86)		130 (5.11)	
33,558		Side	687 @ 0	(27.07 @ 0)	*297 @ 18,288	(11.7 @ 20,000)	*229 @ 27,432	(9.0 @ 30,000)
33,558		Deck	—		*79 (3.1)		145 (5.7)	
36,200	(39,589)	Side	742 @ 0	(29.23 @ 0)	419 @ 18,000	(16.50 @ 19,685)	304 @ 27,000	(11.98 @ 29,527)
36,200	(39,589)	Deck	—		75 (2.96)		126 (5.02)	
37,550	(41,065)	Side	748 @ 0	(29.43 @ 0)	393 @ 22,000	(15.49 @ 24,060)	331 @ 27,000	(13.12 @ 29,528)
37,550	(41,065)	Deck	—		105 (4.15)		138 (5.44)	
33,924	(37,100)	Side	668 @ 0	(26.29 @ 0)	*285 @ 18,288	(11.2 @ 20,000)	— @ 25,603	28,000
33,924	(37,100)	Deck	—		*72		*121 (4.75)	
41,700	(45,604)	Side	713 @ 0	(28.08 @ 0)	342 @ 23,000	(13.46 @ 25,153)	292 @ 27,500	(11.48 @ 30,114)
40,600	(44,401)	Deck	—		87 (3.47)		110 (4.32)	
35,271	(38,573)	Side	622 @ 0	(24.48 @ 0)	323 @ 18,288	(12.73 @ 20,000)	231 @ 27,432	(9.08 @ 30,000)
34,766	(38,021)	Deck	—		77 (3.02)		130 (5.11)	
41,900	(45,822)	Side	604 @ 0	(23.79 @ 0)	291 @ 18,288	(11.47 @ 20,000)	205 @ 27,432	(8.08 @ 30,000)
42,500	(46,479)	Deck	—		48 (1.87)		76 (2.99)	
41,900	(45,822)	Side	604 @ 0	(23.79 @ 0)	291 @ 18,288	(11.47 @ 20,000)	205 @ 27,432	
42,500	(46,479)	Deck	—		48 (1.87)		76	

Bibliography

The technical details in this work are based upon official documents of those nations concerned, primarily upon those found in the design archives, supplemented by official reports and material from books or articles by noted authorities on the subject of warship design, construction, or operation. The authors and their representatives were permitted access to classified material and this included:

- design histories
- ship characteristics
- battle-damage reports

Such material was of fundamental importance, as it was this largely unpublished data that permitted a systematic investigation and analysis of the evolution of the design of the various classes of ships, including a detailed study of the design as contracted by the navies concerned. A detailed correspondence with naval constructors and recognized experts familiar with the design evolution was of great assistance to the authors.

The technical data was supplemented by battle-damage reports, special incident reports, and other operational information made available by the archives or navy department of the country concerned.

The actual characteristics of the ships as built were obtained from official sources—such as the ships' operation booklets and numerous official plans—and from general information from noted authorities in the countries considered in this work. The latter was cross-checked with shipyard information and official data from the navy concerned to verify its authenticity.

France. Few published sources were available on the design or operation of French capital ships. This fact was further complicated by the incompleteness of the French archives on the design, construction, and operation of the *Dunkerque*- and *Richelieu*-class ships because of the German military occupation of both Paris and the major shipyards from June 1940 through July 1944 (Paris), or May 1945 in the case of the Brest Navy Yard. In many instances, the plans and files had been scattered and were never completely reorganized. However, the Service Technique des Constructions et Armes Navales (STCAN), the French Military Mission to Washington (Commander A. P. Laget), the French naval attaché (Rear Admiral E. Chaline), and individuals such as Henri Le Masson and Jean Meirat gave the authors much assistance in the absence of complete official documents. The translation of official French documents was accomplished by Mr. Richard van Hooff, a naval architect and marine engineer, who also aided in their analysis.

In January 1962, Mr. Garzke visited the offices of STCAN in Paris at the invitation of Ingénieur Général du Génie Maritime Amiot. Discussions were held at that time on

the design of the *Richelieu*-class battleships and the war damage sustained by the *Jean Bart* and *Richelieu*. This assistance continued through written correspondence and later included information on the battlecruisers *Dunkerque* and *Strasbourg*. Considerable technical data—including the preliminary design history of the *Richelieu*—and a number of official plans were eventually furnished. This was further supplemented by the assistance of the French Military Mission to Washington, the French naval attaché, and the Chantiers de l'Atlantique, Penhoët-Loire.

Individual assistance provided by Henri Le Masson and Jean Meirat was extremely helpful in describing the operations and battle damage of the *Dunkerque*, *Strasbourg*, *Richelieu*, and *Jean Bart*. In this regard Mr. A. David Baker III also provided helpful information from his files. M. Le Masson provided information from his personal library and files on the design and operations of all French ships. This was supplemented by interviews with former naval constructor personnel and visits to the naval archives. M. Jean Meirat furnished detailed information on the wartime operation of the completed French ships and also provided much material from his personal files. Both gentlemen over the years of manuscript development provided detailed criticisms and additional information when it was requested.

Preliminary manuscripts were reviewed for completeness and accuracy by several noted authorities on French warship design, such as Vice-Amiral Paul Morel, who was the chief naval constructor at the time of the *Richelieu*'s construction, and Contre-Amiral Lucien Poirer who took part in the building, sea trials, and first months of operation of the *Richelieu*. Ingénieur Général Pascal reviewed the text and provided several key plans and data.

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Netherlands. Research into the history of Dutch capital-ship design was difficult, because so few sources were available. The individuals who did contribute to the project, however, not only had access to naval historical archives but were professionals who had been personally involved in the genesis of the Dutch battlecruiser design.

Most helpful was the late R. F. Scheltema de Heere, long a naval constructor with the Dutch navy, who furnished translations of his written technical papers, provided historical analysis of ships' characteristics data, and over several years offered detailed analysis and criticism of the manuscript. Mr. L. L. von Münching, Librarian of the Department of Defense (Navy), provided a copy of his own history of the battlecruiser design, and much additional information. Assistance was also given by Commodore J. F. van Dulm, RNN (retired), Chief Naval Historian, and Mr. I. van der Ham, Assistant Professor in Naval Architecture, Delft University, who as a young naval constructor was associated with the battlecruiser design.

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United Kingdom. The chapters concerned with British battleships were researched with the superb cooperation of the Ministry of Defence, Naval Home Division, the Naval Historical Branch of the Ministry of Defence, and the Director

General of Ships, Admiralty, Bath. Mr. Garzke, the first foreign national accorded the privilege, visited the Admiralty offices at Foxhill, Bath, to commence the authors' research and to establish contacts who would later provide assistance in gathering information on the design, construction, and operation of the *King George V* and *Lion* classes and the HMS *Vanguard*.

The Ministry of Defence also assisted in locating key officers who served on several ships of the *King George V* class, considerably helping to develop and refine the historical narratives. In addition, these officers checked the authors' historical and technical accounts, and the Naval Historical Branch answered important detailed questions involving ship operations in the Royal Navy during World War II. In this regard, the authors found Rear Admiral P. N. Buckley, C.B., D.S.O., very helpful.

Dr. Ian L. Buxton and Messrs John Campbell and Patrick Mahoney were of considerable help to the authors. Dr. Buxton provided much assistance, providing the benefits of his overall insight into the ship design process, in addition to substantial historical-technical research on behalf of the authors. Additionally, Dr. Buxton gave unstintingly of the fruits of his personal research into matters dealing with British naval ordnance and battleship construction. Mr. John Campbell assisted the authors in providing technical data, particularly on naval ordnance matters. Patrick Mahoney provided the authors with insight into the sinking of the *Prince of Wales* and *Repulse* from his own research and writings. In fact, a book he coauthored with Martin Middlebrook on the loss of the *Prince of Wales* was the final check in the authors' research on this subject.

Although such standard references as Parkes's *British Battleships*, various editions of *Janes Fighting Ships*, Raven's and Roberts's *British Battleships of World War II*, and certain volumes of the *Transactions of the Royal Institute of Naval Architects* were of general value to the background of the design development of battleships for the Royal Navy, the bulk of the key data and information resulted from a voluminous correspondence with the Naval Home Division of the Ministry of Defence. Particularly helpful in this were Messrs D. B. Omand, A. J. H. Ward, and K. Woolgar. The authors also had their text reviewed by certain of the naval constructors who were involved in the design of these ships. Among those were Messrs F. S. Sutherby (Assistant Director of Naval Construction under Sir Stanley Goodall) and G. Bryant, who described much of the design philosophy that does not appear in the official histories or correspondence.

The historical narratives concerning the *King George V*, *Prince of Wales*, and *Duke of York* were written after consultations with officers who served on these ships in conjunction with the voluminous historical literature available on these and other ships described in this book.

The authors were particularly anxious to clarify the somewhat conflicting and often inaccurate accounts of the damage sustained by the *Prince of Wales* during her battle with the *Bismarck* and *Prinz Eugen* on 24 May 1941, and her loss in the South China Sea on 10 December 1941. The authors reviewed battle damage reports, the reports of committees set up to study the reasons for her loss, various published accounts of her loss, the design history, and official plans of the ship. A Royal Navy Clearance Diving Team report on the wreckage of the *Prince of Wales* was extremely valuable in determining the extent of the torpedo damage. A preliminary text was sent to certain key senior surviving officers of the *Prince of Wales*, such as Captain Collin McMullen, RN (Ret.)—Gunnery Officer; Commander A. G. Skipwith, RN (Ret.)—Executive Officer; and Rear Admiral D. B. H. Wildish, RN (Ret.)—officer in charge of "B" Engine Room (as a lieutenant commander). Based on their comments, a more accurate account of the loss could be presented in this volume. Admiral Wildish was the key contact; he provided many valuable additions to the text and assisted in

securing comments from naval constructors who were acquainted with the design of the *King George V* class.

The authors also had the assistance of Commodore Geoffrey T. Marr, RN (Ret.) and Commander J. J. Casemate, who served aboard the *King George V*, for clarifications of the operations of their ship. Also helpful in the description of the problems with the 14-inch guns was Rear Admiral H. C. Leach, RN, son of Captain John Leach of the *Prince of Wales*. Admiral Leach served as a turret officer on the *Duke of York* and was on board when this battleship fought the *Scharnhorst* in 1943.

In addition to the aid of the Royal Navy, the authors also had the privilege of the extensive assistance of Vickers Armstrongs, builders of the *King George V* and the 14-inch guns of all sister ships, and Cammell Laird, Birkenhead, builders of the *Prince of Wales*. Vickers Armstrongs provided far-reaching and detailed technical assistance and a review of the preliminary text. John Brown, Clydebank—builders of the *Duke of York* and *Vanguard*—Swan Hunter and Wigham Richardson and the Fairfield Ship-building and Engineering Company were also helpful. Yarrow and Company, Ltd., provided an important contribution to the discussion of the propulsion plants of British battleships.

The book by Raven and Roberts provided a final check on the authors' research on the preliminary designs of the *King George V*, *Lion*, and *Vanguard*.

All the drawings in the text were based upon original plans procured from the Ministry of Defence or the National Maritime Museum, but modified where photographic evidence dictated.

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Union of Soviet Socialist Republics (Russia). Unfortunately, there is little primary source material available on Soviet capital-ship design and construction, a consequence of the penchant for secrecy that is so characteristic of the Soviet dictatorship.

There is very good background material available, however, on the Russian efforts to obtain foreign technical and material assistance. Of these, *Foreign Relations of the United States, Diplomatic Papers, The Soviet Union, 1933-1939*, is particularly helpful. The design archives of Gibbs and Cox, Inc., were very generously made available to the authors, thereby providing much useful information concerning Gibbs and Cox's dealings with the Soviets in the prewar period.

The authors are profoundly grateful to Messrs Rolf Erikson and Jürgen Meister, whose exhaustive research into Soviet naval history was most helpful in clarifying many areas of uncertainty. Mr. Erikson's magazine article is, perhaps, the best presentation on these ships to be published to date.

In recent years, several helpful, but brief, articles have appeared in Western naval periodicals regarding these ships, and very limited data has been provided in the Soviet naval literature.

German intelligence reports on the Soviet ships appear in the very useful Tambach Archives, captured German archival materials microfilmed and retained by the Office of Naval History, U.S. Department of the Navy.

A number of wartime and postwar U.S. Navy intelligence reports have been declassified in recent years. These are helpful in providing a number of attaché reports of wartime shipyard visits, as well as postwar German prisoner-of-war interviews.

In their discussions on Soviet capital-ship design, more so than any other chapter in this volume, the authors of necessity have had to rely on secondary sources as well as naval architectural estimates of reasonable attributes for these relatively little-known Soviet ships.

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